STUDY SUPPORTING THE EVALUATION OF DIRECTIVE 2009/128/EC ON THE SUSTAINABLE USE OF PESTICIDES AND IMPACT ASSESSMENT OF ITS POSSIBLE REVISION

Final Impact Assessment Report

Written by Ramboll and Arcadia International
For the Directorate General for Health and Food Safety
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Contact: Mr Andrew Owen-Griffiths
E-mail: andrew.owen-griffiths@ec.europa.eu

European Commission
B-1049 Brussel

Study supporting the Evaluation of Directive 2009/128/EC on the Sustainable Use of Pesticides and Impact Assessment of its possible revision

Final Impact Assessment Report

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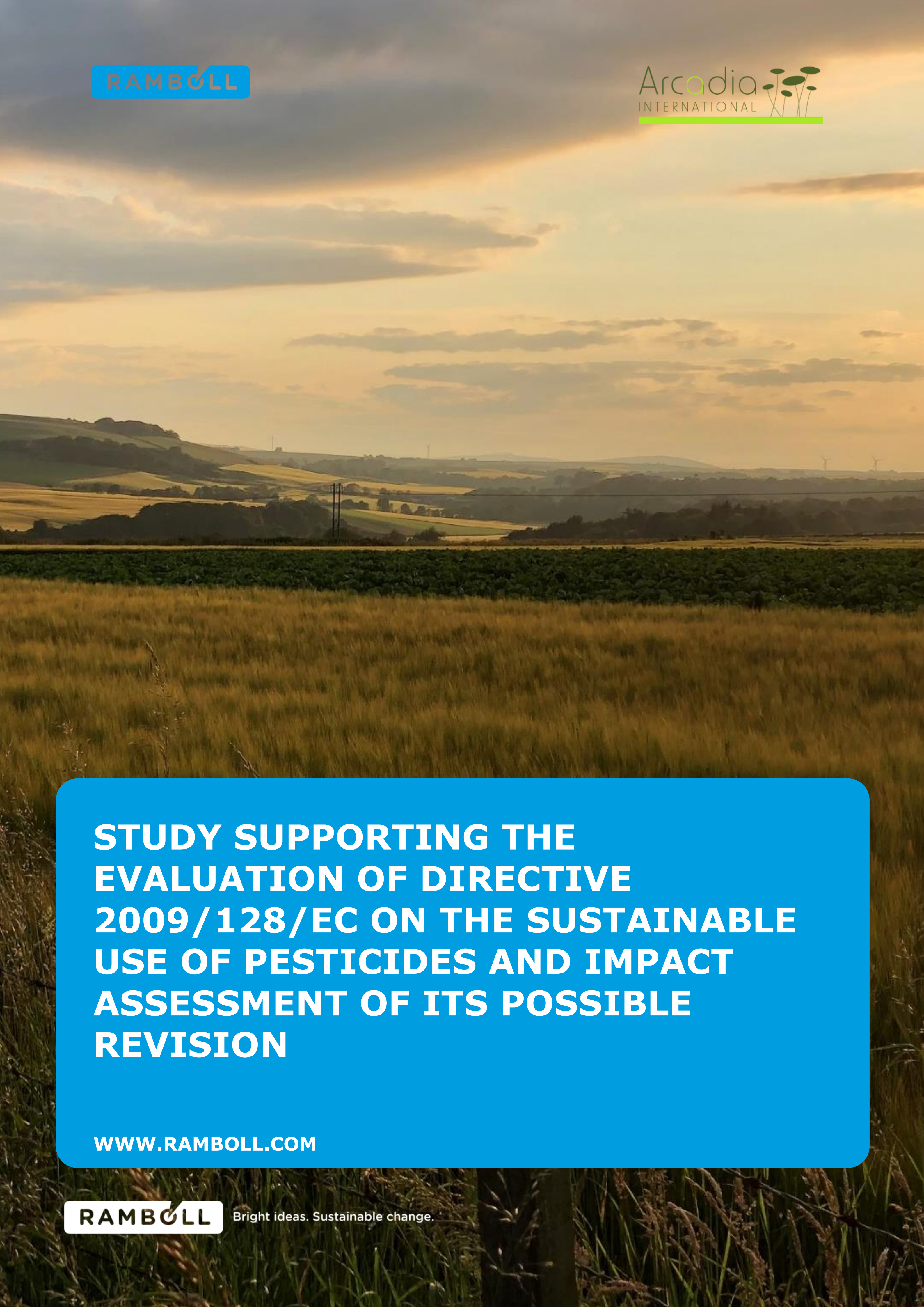

STUDY SUPPORTING THE EVALUATION OF DIRECTIVE 2009/128/EC ON THE SUSTAINABLE USE OF PESTICIDES AND IMPACT ASSESSMENT OF ITS POSSIBLE REVISION

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Reference
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Abstract

The European Commission is undertaking a back-to-back evaluation of Directive 2009/128/EC on the sustainable use of pesticides (SUD) and impact assessment of its possible revision. This support study provides an assessment of the potential environmental, economic and social/human health impacts of achieving the Farm to Fork (F2F) Strategy pesticide use and risk reduction targets by 2030, as well as an assessment into the impacts of possible revisions to the SUD.

Overall, achieving the F2F targets related to pesticides would likely generate environmental and social/health benefits, and contribute to a sustainable and safe food production in the EU. However, the pesticide targets in the F2F Strategy would need to be accompanied by strong action on habitat loss to reverse current negative trends in biodiversity loss. Economic impacts would be expected along the food value chain, mainly negative in conventional agriculture and trade, which could be mitigated through policy intervention. The possible revisions of SUD would likely bring additional costs for professional pesticide users and the expected gain would be a reduced use (cost) of pesticides, which could potentially offset the direct costs.

Executive summary

Overview to the study

On the 29th of May 2020 the Commission published a combined evaluation roadmap and inception impact assessment on the SUD. This support study aims at collecting evidence to support the corresponding ex-post evaluation of Directive 2009/128/EC on the sustainable use of pesticide (the SUD) and the impact assessment (IA) of the possible future SUD revision initiated by the Commission. In line with the European Green Deal and the Farm to Fork (F2F) Strategy to ensure a fair, healthy and environmentally friendly food system and complementary to the EU Biodiversity Strategy for 2030, measures will be brought forward with the aim to significantly reduce the use and risk of chemical pesticides, building on the existing evidence and the additional assessment carried out by the Commission.

The approach adopted in this study for the IA part (as for the evaluation part) closely follows the provisions from the Commission set out in the Better Regulation Guidelines, including extensive stakeholder consultation through interviews, surveys, focus groups, workshops and the public consultation that was open between January and April 2021.

Based on the evaluation and in close exchange with the Commission, this study has analysed the problems and underlying drivers in the field of sustainable pesticide use. This analysis resulted in four problem areas to be addressed in the revision of the SUD. In line with these problem areas the Commission developed policy elements of least, medium and most ambition to be subject to the impact assessment. The four groups of policy elements are:

- alignment with pesticide-related targets announced in the F2F Strategy
- strengthening current SUD provisions
- improving data availability and monitoring
- addressing new technologies

In each of these four groups, multiple options were developed by the Commission. Because of the different components of the objectives and elements, this study necessitates two strands of impact assessment to cover the impacts as comprehensively as possible:

1. First, an assessment of the social, economic and environmental impacts of the F2F pesticide targets was undertaken to determine the consequences of the two targets.
2. Second, an assessment of the specific policy elements developed by the Commission in the four groups on the economic impacts and benefits they create for different stakeholder groups.

The relevant and significant impacts were assessed qualitatively, quantitatively and in monetary terms whenever possible.

Assessment of social, economic and environmental impacts of the F2F pesticide targets

As part of this IA, the F2F pesticide targets were assessed for their potential impacts on human health/social, macro and microeconomics and the environment should the targets become legally binding. Crucially, the IA looked at the possible impacts of achieving the targets by 2030. The following points aim to synthesise this analysis:

- **Environmental Impacts**: The outlook in the baseline scenario to 2030 for all indicators is bleak with further declines in biodiversity and related ecosystem services according to reports by the European Environment Agency, the EU Ecosystems Assessment and researchers. The impact of pesticides and pesticide-related targets in the F2F Strategy make a contribution. Additional policies directed at protecting pollinators (e.g. EU Pollinator Initiative) and water quality and biological pest control (e.g. integrated pest management, IPM) will help, but habitat loss has a greater impact, whereas pesticides are one part of the problem. The assessment is that strong action is needed on other pressures to complement the efforts on pesticide reduction to reverse current trends.

- **Economic Impacts**: A potential decrease in agricultural production compared to the baseline, driven by an overall reduction in yield and, for certain cereals and oilseeds, also a reduction in cropped area, is expected to induce production price increases. Similarly, trade effects would influence producer prices over the medium to long term, further challenging the economic return of farmers. These impacts could however be mitigated through adjustments to the CAP framework and targeted development of alternatives to (more hazardous) pesticides. The evolution of the food industry and distribution/wholesale indicators is not anticipated to be widely impacted by achieving the F2F pesticide targets beyond the potential impacts on producer and wholesale prices, which may have an impact on food prices. None of the options or targets has extraterritorial legal implication outside the EU.
- **Social/ Health Impacts**: Meeting the F2F targets is anticipated to create a reduction in the likelihood of exposure of consumers to pesticides in food and beverages. Similarly, a move to the use of less hazardous chemical pesticides is expected to reduce overall exposure by professional users, lowering the likelihood of adverse health effects that are attributed to pesticide exposure. Additionally, the exposure of the general public and particularly vulnerable groups to more hazardous pesticides will be reduced together with related negative health impacts. Potential increases in food prices could force people to adjust as consumer purchasing power decreases and this could have a negative impact on household dietary choices and nutrition.

Comparison of combinations of policy elements

The comparison of policy elements assesses each element on the economic impacts and benefits they create for different stakeholder groups. Over the four group of policy elements, the following points summarise the findings:

- **Aligning the SUD with pesticide-related targets of the F2F Strategy** can take the form of aspirational EU level targets or legally binding targets, which would create policy planning and reporting costs for Member States depending on the implementation. Measures to reduce the use of more hazardous substances (e.g. prescription system, ban in sensitive areas) has the potential of high costs for professional users but also for targeted benefits.
- **Strengthening the current SUD provisions** focuses on IPM operationalisation, testing of pesticide application equipment, training, and the effectiveness of national action plans (NAPs). These elements are found to create likely costs for professional users and Member State authorities. The magnitude of impacts varies for each stakeholder group and depends on the concrete features of the approach chosen.
- **Improving data availability and monitoring** would ensure a better understanding of the use of pesticides, and therefore the key risk topics as well as data collection on specific impacts. Professional users would see costs for the submission of use data that is already recorded under Reg. (EC) 1107/2009, while Member State authorities likely face costs from the analysis.
- **Addressing new technologies** aims to improve the account taken of precision farming, aerial spraying with drones and other emerging technologies. These elements focus on the future promotion and have direct economic impacts only to the Commission and Member States.

Based on the assessment of these elements and the overall F2F pesticide targets, different possible policy options of combinations of elements are assessed, including an option defined as the preferred option by the Commission.

Contents

1. Introduction

1.1 Aim and structure of the report

This document is the Final Report of the project "Study supporting the evaluation of Directive 2009/128/EC on the sustainable use of pesticides[1] and impact assessment of its possible revision".

It presents the results of the Impact Assessment (IA) part of the assignment covering the questions from the terms of reference for the study, in particular an in-depth analysis of identified problems, drivers, objectives and the proposed policy options. Further, it presents the dynamic baseline scenario, including the main indicators that were used to build the baseline and subsequently the IA of policy options.

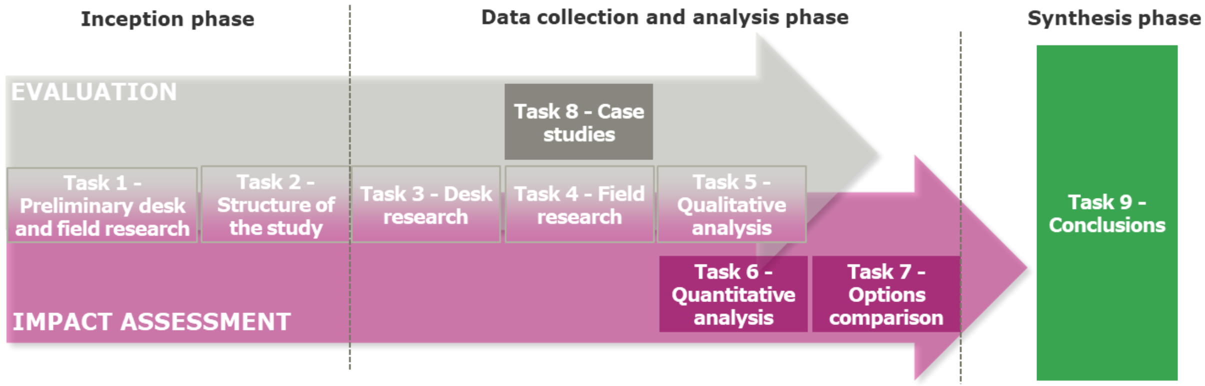
The report structure follows and complies with the current Commission template for SWD on impact assessments.

1.2 Methodology

1.2.1 Overall process

This study is part of a back-to-back evaluation and impact assessment, to evaluate the Directive after ten years of implementation (considering that Member States were to transpose the SUD as of November 2011, some provisions came into force at later dates). As such, the methodological approach to the study contains activities that feed into both the evaluation and impact assessment parts. The figure below illustrates the back-to-back process and the data collection activities in relation to both the evaluation and the impact assessment parts.

Figure 1.1. Overview of tasks under the back-to-back study



EU legislation is prepared and adjusted based on transparent, comprehensive and balanced evidence on the advantages and disadvantages of possible policy options by assessing their potential impacts. Impact Assessment is a tool to help structure reflection and conduct analyses informing policy design. It sheds light on the economic, social (including health) and environmental dimensions of policy proposals based on an analysis of the issue at stake through stakeholder engagement and research. The ultimate goal is to develop the most pertinent policy options. As such, the IA explains why, and which policy actions could be taken at the EU level and provides

[1] In the context of this study, pesticides have to be understood as plant protection products

evidence to respond to concerns that are likely to arise in the decision-making process or the public reaction after the Commission adopts the initiative.

With the Better Regulation Guidelines and the Better Regulation Toolbox, the European Commission has well-established procedures and specific guidelines in place for carrying out evaluations and impact assessments. The overall approach for the impact assessment follows closely those provisions to ensure the application of best practice.

Assessment of impacts of policy options

The identification of economic, social and environmental impacts of the policy options and who will be affected are one of the central pillars of this IA. Ultimately, the analysis seeks to identify to what extent different policy options to revise the SUD would meet the defined objectives, with what benefits, at what cost, and with what implications for different stakeholders.

This step follows the method laid out in the Toolbox[2] which provides an overview of potential key impacts which should be screened to identify potentially important impacts (considering both positive/negative, direct/indirect, intended/unintended as well as short/long-term effects). To this end, the Guidelines and Toolbox provide a wide range of methodologies which are considered and adapted for the assessment of impacts as part of this IA. This includes the assessment of the most significant impacts qualitatively, quantitatively and in monetary terms whenever possible. Impacts are also assessed from the point of view of society as a whole, although distributional effects and cumulative burdens on individual parties are proportionately assessed and considered. The policy options and their elements have been assessed and compared on the criteria of their impacts on various stakeholders, their effectiveness, proportionality, efficiency, coherence and subsidiarity. The approach used for this assessment is detailed in Chapter 6.

The report also places additional credence on making sure that environmental and socio-economic impacts are simultaneously addressed in a balanced way to protect non-target organisms (biodiversity) and human health and to safeguard the competitiveness of European agriculture.

The study is divided into nine key tasks. Apart from the tasks pertaining to the design of the study and synthesis of evidence, the remaining tasks included a number of different sets of analysis and data collection activities. Data collection activities included desk research on relevant literature and statistical information and field research in the form of targeted interviews, three targeted surveys, seven topical case studies and a public consultation. Analysis tasks included analysing the state of implementation, the evaluation baseline and the public consultation.

1.2.2 *Stakeholder consultations*

The following table provides an overview of the stakeholder consultations, the dates of distribution and the number of responses.

[2] E.g. Tools #20 - #24, #26, #29, #57 - #62 and others

Table 1-1.1. Consultation activities

Consultation method	Stakeholder activities/ groups	Dates	No. of responses	Part of the Evaluation or Impact Assessment
Targeted interviews	• EU Commission services and agencies, Member State authorities, International organisations, Consumer organisations, Economic stakeholders - PPP producers and distributors, NGOs, Research and Academia, Other economic stakeholders impacted by SUD, Workers organisations	5th-31st March 2021	53 interviews with 82 persons	Both
Targeted surveys (3)	• Survey questionnaire to Member States, Iceland and Norway SUD competent public authorities and related authorities	18th June-23rd July 2021	53 responses from 27 Member States +Norway and Iceland	Both
	• Survey questionnaire to professional users of PPP and other industry stakeholders	19th July - 27th August 2021	161 responses	
	• Survey questionnaire to environmental NGOs, Consumer Organisations and civil society organisations		28 responses	
Focus groups (6)	• Identifying environmental and human health impacts of the policy options	6th July 2021	2 EU institution representatives, 1 academic and 1 environmental consultant	Impact Assessment
	• Identifying impacts of policy options on non-EU countries (trade flows, sustainable farming practices, development)	7th July 2021	3 international institutions, 1 international private sector initiative and 1 academic	
	• Identifying macroeconomic impacts of the policy options		2 EU institution representatives, 1 public research institute and 2 think tank representatives	
	• Increasing the uptake of IPM (including enforcement) and monitoring of progress	1st Sep 2021	2 academics, 4 research institutes	
	• Contribution of drones and precision farming to reduction of pesticide risk and use		2 academics, 4 research institutes	
Workshops (2)	• SUD Study – Validation Workshop on the evaluation and future revision of the SUD.	4th May 2021	59 Participants	Evaluation and Impact Assessment
	• SUD Study – Final Validation Workshop on the study findings	6th October 2021	64 Participants	
	• Sustainable use of pesticides - first remote stakeholder event	19th January 2021	269 Participants	

Consultation method	Stakeholder activities/ groups	Dates	No. of responses	Part of the Evaluation or Impact Assessment
	• Sustainable use of pesticides - second remote stakeholder event	25th June 2021	250 Participants	
	• Sustainable use of pesticides - third remote stakeholder event	5th October 2021	215 Participants	
Public Consultation	• Public Consultation (PC) on the evaluation and impact assessment of Directive 2009/128/EC establishing a framework for community action to achieve the sustainable use of pesticides.	18th January - 12th April 2021	1640 responses across all stakeholder groups	Evaluation and Impact Assessment

1.2.3 Robustness of data and findings

The robustness of the data collected must be differentiated between the reviewed secondary evidence from literature and the primary data collected in stakeholder consultation activities. The literature and in particular scientific evidence are characterised by a strong divergence in findings depending on the specific case studied (location, crop, farming type, etc.). Regarding stakeholders, the consultation has generated a broad and comprehensive picture of different stakeholders' views and opinions. Further details can be found in the synopsis report of stakeholder consultation for this activity.

The resulting overall robustness of findings is limited by the strong interdependencies between policy instruments, impacting factors on environment, human health and economy, as well as diverse agricultural conditions across Europe. However, the impact assessment of F2F targets and policy options based on a large body of evidence offers reliable insights on the EU level.

1.3 Context of the impact assessment

This section explains the context of the IA in five areas. First, a general overview of the reasons leading to the evaluation of the SUD, combined with a back-to-back impact assessment are presented. These will be complemented with a summary of evaluation findings, an overview of the policy context, the stakeholder landscape and the governance of the SUD.

1.3.1 Reasons leading towards the back-to-back evaluation/impact assessment

This IA is the second phase of a back-to-back evaluation impact assessment, meaning that a possible revision of the SUD was already foreseen before an evaluation had been conducted. This was done for three main reasons:

- Indications that the SUD has not achieved its full potential;
- Harmful effects on the environment and human health from use of pesticides continue to exist, creating potential risks for biodiversity; and
- Recent related policy developments, namely the Green Deal and the F2F Strategy.

These reasons are further expanded upon in the following sections.

1.3.1.1 *Indications that the SUD has not achieved its full potential*

Indications that the SUD has not achieved its full potential came from multiple sources. A 2017 report from the EC on Member State National Action Plans and on progress in the implementation of the SUD[3] found, among others, that there were significant gaps in National Action Plans as well as in the implementation of the SUD. A 2020 report, also from the EC and assessing the experience gained by Member States on the implementation of national targets on the progress of implementation[4] confirmed weaknesses in the implementation of several provisions of the SUD, including the enforcement of IPM. Similarly, a study commissioned by the European Parliament Research Service[5] finds progress in many Member States but limited achievement of the SUD's objectives overall, in particular due to the variety in implementation of IPM across the Member States. Finally, a recent report from the European Court of Auditors[6] found that there is limited evidence in reducing and measuring risks from the use of pesticides.

1.3.1.2 *Harmful effects from use of pesticides continue to exist*

Several recent policy strategies and initiatives aim to address **environmental challenges**, including biodiversity loss. The two most prominent examples are the F2F Strategy and the Biodiversity Strategy. As pointed out in the former, "the use of chemical pesticides in agriculture contributes to soil, water and air pollution, biodiversity loss and can harm non-target plants, insects, birds, mammals and amphibians".

The risk of using pesticides is also a matter of strong concern in society in general and among European citizens. The recently concluded European Citizens Initiative "Save Bees and Farmers[7]" generated 1.2 million signatures, calling on the European Commission and European Parliament to act for the use of synthetic pesticides to be gradually reduced by 80 percent in EU agriculture by 2030 and completely phased out by 2035, and thus needs to be considered by the European Institutions.

At a global level, the Food and Agriculture Organization of the United Nations (FAO) published the first global assessment of biodiversity for food and agriculture (BFA) in 2019[8], which stresses the international level of concern for biodiversity loss. The State of the World's Biodiversity for Food and Agriculture provides an assessment of biodiversity for food and agriculture (BFA) and its management worldwide, drawing on information provided in 91 country reports, 27 reports from international organizations and inputs from over 175 authors and reviewers. The term biodiversity for food and agriculture is used to define the diversity of animals, plants and micro-organisms at the genetic, species and ecosystem levels that sustain structures, functions and processes in and around production systems and provide food and non-food agricultural products.

[3]COM(2017) 587 Final Report from the Commission to the European Parliament and the Council on Member State National Action Plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides. See: https://ec.europa.eu/food/system/files/2017-10/pesticides_sup_report-overview_en.pdf

[4] COM(2020) 204 final report from the Commission to the European Parliament and the Council on the experience gained by Member States on the implementation of national targets established in their National Action Plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides. See: https://ec.europa.eu/food/system/files/2020-05/pesticides_sud_report-act_2020_en.pdf

[5] EPRS (2018). Directive 2009/128/EC on the sustainable use of pesticides. European Implementation Assessment. See: https://www.europarl.europa.eu/RegData/etudes/STUD/2018/627113/EPRS_STU(2018)627113_EN.pdf

[6] Special Report 05/2020: Sustainable use of plant protection products: limited progress in measuring and reducing risks. See: https://www.eca.europa.eu/en/Pages/DocItem.aspx?did=53001

[7] https://www.savebeesandfarmers.eu/eng

[8] FAO. 2019. The State of the World's Biodiversity for Food and Agriculture, J. Bélanger & D. Pilling (eds.).FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome. 572 pp.(http://www.fao.org/3/CA3129EN/CA3129EN.pdf)

The FAO report concludes that many key components of biodiversity for food and agriculture are in decline at genetic, species and ecosystem levels. Many species that contribute to vital ecosystem services, including natural pest enemies, pollinators, soil organisms and wild food species, are in decline due to habitat destruction, overexploitation, and pollution, amongst other threats. Many key ecosystems that deliver essential services for food and agriculture, including protection against natural hazards such as storms and floods, are also rapidly declining. It is estimated that 50% of land in the EU cultivated with crops dependent on pollinators face a pollination deficit. Reports show that biodiversity loss is, amongst other factors, driven by the use of pesticides[9].

Drivers of change reported include major global trends such as changes in climate, international markets and demography that give rise to more immediate drivers such as land-use and water management changes, pollution, overuse of external inputs (including pesticides), proliferation of invasive species, degradation of forests and aquatic ecosystems, transition to intensive production of a reduced number of species, breeds and varieties and overharvesting. Many of these drivers are caused by inappropriate agricultural practices, and individual effects of each driver are often exacerbated by interactions between them. The LUCAS project will increase the number of soil samples and the range of pesticides being analysed to gain more information in this area[10].

In the EU, a reduction of species, in particular insects and pollinators, has been established in several studies[11]. Agroecosystems host some of the most species-rich habitats in the EU[12] with an estimated 50% of all species relying on agricultural habitats at least to some extent[13]. In this context, reports show that biodiversity loss is – amongst other factors – connected to the use of pesticides[14] while EU policy instruments have not been able to stop this trend[15]. However, it is

[9] Maes, J., et.al., Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN, Publications Office of the European Union, Ispra, 2020, ISBN 978-92-76-17833- 0, doi:10.2760/757183, JRC120383. European Court of Auditors (2020). Press Release Luxembourg, 5 June 2020; Powney, G.D., Carvell, C., Edwards, M. et al. Widespread losses of pollinating insects in Britain. Nat Commun 10, 1018 (2019). https://doi.org/10.1038/s41467-019-08974-9;
Hallmann, C. A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H., Stenmans, W., Müller, A., Sumser, H., Hörren, T., Goulson, D., and de Kroon, H. (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLOS ONE, 12(10), e0185809. https://doi.org/10.1371/journal.pone.0185809

[10] Cristiano Ballabio, Panos Panagos, Emanuele Lugato, Jen-How Huang, Alberto Orgiazzi, Arwyn Jones, Oihane Fernández-Ugalde, Pasquale Borrelli, Luca Montanarella. (2018). Copper distribution in European topsoils: An assessment based on LUCAS soil survey. Science of The Total Environment, Volume 636, Pages 282-298, https://doi.org/10.1016/j.scitotenv.2018.04.268.

[11] Gary D. Powney et al., "Widespread Losses of Pollinating Insects in Britain," *Nature Communications* 10, no. 1 (December 1, 2019): 1–6, https://doi.org/10.1038/s41467-019-08974-9; Caspar A. Hallmann et al., "More than 75 Percent Decline over 27 Years in Total Flying Insect Biomass in Protected Areas," ed. Eric Gordon Lamb, *PLOS ONE* 12, no. 10 (October 18, 2017): e0185809, https://doi.org/10.1371/journal.pone.0185809; Holzschuh Potts S., Biesmeijer K., Bommarco R., Breeze T., Carvalheiro L., Franzén M., González-Varo J.P. et al., *STATUS and TRENDS of EUROPEAN POLLINATORS*, ed. STEP Project (Sofia: Pensoft Publishers, 2015), https://www.researchgate.net/publication/272019008_Status_and_trends_of_European_pollinators_Key_findings_of_the_STEP_project.

[12] Wilson, J.B., Peet, R.K., Dengler, J. and Partel, M. (2012). Plant species richness: the world records. Journal of Vegetation Science, 23:796–802

[13] Halada, L., Evans, D., Romao, C. and Petersen, J.-E. (2011). Which habitats of European importance depend on agricultural practices? Biodivers. Conserv. 20:2365–2378. Lomba A., Alves P., Jongman R.H., McCracken D.I. (2015). Reconciling nature conservation and traditional farming practices: a spatially explicit framework to assess the extent of High Nature Value farmlands in the European countryside. Ecol Evol. 5(5):1031–1044

[14] OECD (2020). Managing the Biodiversity Impacts of Fertiliser and Pesticide Use. https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2020)2&docLanguage=En. Sanchez-Bayo, F., Wyckhuys, K. A. G. (2019), Worldwide decline of the entomofauna: A review of its drivers, Biological Conservation and IPBES (2019). Global assessment report on biodiversity and ecosystem services.

[15] European Court of Auditors (2020). Special report 15/2020: Protection of wild pollinators in the European Union - Commission initiatives have not borne fruit

extremely difficult to ultimately link the cause to the effect. The extent to which pesticide use contributes to biodiversity decline in a system of many interlinked factors cannot be precisely established. This is further amplified by effects on air quality that have been found in EU samples and linked to medium to long range distances and reach remote areas[16].

Pesticides can also reach surface and groundwater bodies and impact these ecosystems. According to an EEA report[17], chemical pesticides are widely detected in both types of water bodies. However, the levels are often too low to give reason for concern. For instance, 6.5% of the groundwater area failed to achieve good chemical status as a result of pesticide detection, while still being the second most common type of chemicals to lead to such failure. For the chemical status of surface water bodies, pesticides are found not to be a problem, with only 0.004% of surface water area failing good status because of them. Other reports, however, show that for rivers and lakes over the period 2007 - 2017, between 5 – 15 % of water monitoring stations showed exceedances of environmental quality standards by herbicides and 3 – 8 % by insecticides. Exceedances in groundwater were 7 % for herbicides and less than 1 % for insecticides[18]. The majority of exceedances in surface water related to active substances approved for use in pesticides, whereas the majority of breaches of groundwater quality were due to active substances which were no longer permitted for use in pesticides, but the persistent nature of these substances meant that their presence could be detected many years after their use[19].

The EU initiative "Mapping and Assessment of Ecosystems and their Services" (MAES)[20] provided a coherent analytical framework for the EU Ecosystem Assessment – an analysis of the pressures and condition of terrestrial, freshwater and marine ecosystems and their services based on European data relative to the baseline year 2010. The 2020 EU Ecosystem Assessment covers the total area of the EU and the UK (as well as marine regions). The analysis of the trends in condition in agroecosystems is based on 14 indicators for which, except for one, short term (2010-2018) and long term (e.g. since 1990 or 2000 to 2018) trends are available. These indicators assess three main characteristics of agroecosystems: environmental quality (nitrogen concentration in groundwater), structure (e.g. crop diversity, share of dominant crop, crop rotation, share of semi-natural elements, connectivity of semi-natural elements, landscape mosaic, farmland bird index, grassland butterfly indicator, wild pollinators indicator, trends in unfavourable conservation status, soil organic matter content, soil biodiversity) and function (gross primary production).

The MAES analysis shows no significant trend for the important indicator of pesticide use, which remains unchanged. However, a reduction in risk to human health and the environment is observed by the EU Harmonised Risk Indicator, together with other trends for structural parameters, landscape mosaic and crop distribution, the share of agroecosystems under protection by EU and

[16] Kruse-Plaß, M., Hofmann, F., Wosniok, W. et al. Pesticides and pesticide-related products in ambient air in Germany. Environ Sci Eur 33, 114 (2021). https://doi.org/10.1186/s12302-021-00553-4
Kirchner, M., Jakobi, G., Körner, W., Levy, W., Moche, W., Niedermoser, B., Schaub, M., Ries, L., Weiss, P., Antritter, F., Fischer, N., Henkelmann, B. and Schramm, K.W. (2016). Ambient Air Levels of Organochlorine Pesticides at Three High Alpine Monitoring Stations: Trends and Dependencies on Geographical Origin. Aerosol Air Qual. Res. 16: 738-751. https://doi.org/10.4209/aaqr.2015.04.0213

[17] EEA, "European Waters. Assessment of Status and Pressures 2018. EEA Report No 7/2018," 2018, https://www.eea.europa.eu/publications/state-of-water.

[18] EEA, "ETC/ICM Report 1/2020: Pesticides in European Rivers, Lakes and Groundwaters - Data Assessment," 2020, https://www.eionet.europa.eu/etcs/etc-icm/products/etc-icm-report-1-2020-pesticides-in-european-rivers-lakes-and-groundwaters-data-assessment.

[19] Mohaupt, V., Völker, J., Altenburger, R., Birk, S., Kirst, I., Kühnel, D., Küster, E., Semeradova, S., Šubelj, G., Whalley, C., 2020, Pesticides in European rivers, lakes and groundwaters – Data assessment. ETC/ICM Technical Report 1/2020: European Topic Centre on Inland, Coastal and Marine waters, 86 pp.

[20] Maes, J., et.al., Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN, Publications Office of the European Union, Ispra, 2020, ISBN 978-92-76-17833- 0, doi:10.2760/757183, JRC120383.

national legislation, as well as soil organic matter. It should be noted that the absence of a clear trend for an indicator can sometimes be caused by the limitations of the approach which are likely to underestimate intensification processes.

Crucially, the overall biodiversity and natural capital stocks of agroecosystems have been suffering long-term degradation and significant biodiversity loss through human activities including the use of pesticides, with those pressures largely unchanged or increasing[21]. Therefore, when additional pressures from a changing climate are considered, the MAES report concludes that the reversal of biodiversity trends and an improvement of ecosystem condition will not take place unless appropriate actions are taken[22].

The direct evidence linking pesticide use to **human health impacts** is scarce, however, there are increasing findings of human health and human development being affected by chemicals, including pesticides[23]. The topic has been researched and discussed for a long time prior to the adoption of the SUD, with recent exemplary findings on users[24], the general public and children as a subgroup[25]. Children are considered particularly vulnerable (including in-utero) due to their development status and small body mass[26]. Potential cocktail effects of exposure to several chemicals are increasingly taking into consideration, which further adds to the relevance of effects on humans, including children and foetuses[27].

From the data reviewed in the meta-analysis conducted by Inserm in 2021[28], it was found that there is a strong presumption of there being a link between exposure to pesticides and six main pathologies. These include non-Hodgkin's lymphoma (NHL), multiple myeloma, prostate cancer, Parkinson's disease, cognitive disorders, chronic obstructive pulmonary disease and chronic bronchitis. These findings are further supported from toxicological studies which point towards mechanisms of action of active substances and families of pesticides that are likely to lead to the health effects demonstrated by epidemiological studies.

[21] Joachim Maes et al., "Mapping and Assessment of Ecosystems and Their Services : An EU Wide Ecosystem Assessment in Support of the EU Biodiversity Strategy." (Luxembourg: Publications Office of the European Union, 2020), https://doi.org/10.2760/757183.

[22] Maes et al.

[23] Pedroso, T., Benvindo-Souza, M., de Araújo Nascimento, F., Woch, J., Dos Reis, F. G., and de Melo E Silva, D. (2021). Cancer and occupational exposure to pesticides: a bibliometric study of the past 10 years. Environmental science and pollution research international, 1–12. Advance online publication. https://doi.org/10.1007/s11356-021-17031-2

[24] Boedeker, W., Watts, M., Clausing, P. et al. (2020). The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. BMC Public Health 20, 1875. https://doi.org/10.1186/s12889-020-09939-0 Patel S. and Sangeeta S., "Pesticides as the Drivers of Neuropsychotic Diseases, Cancers, and Teratogenicity among Agro-Workers as Well as General Public," *Environmental Science and Pollution Research International* 26, no. 1 (January 1, 2019): 91–100, https://doi.org/10.1007/S11356-018-3642-2.

[25] Caroline Linhart et al., "Pesticide Contamination and Associated Risk Factors at Public Playgrounds near Intensively Managed Apple and Wine Orchards," *Environmental Sciences Europe* 31, no. 1 (2019), https://doi.org/10.1186/s12302-019-0206-0.

[26] See HBM4EU (2020). Prioritised substance group: Pesticides. https://www.hbm4eu.eu/wp-content/uploads/2021/02/HBM4EU_AD5.4_Reporting_first_and_second_set_substances_v1.1-1-Pesticides.pdf

[27] ibid.

[28] Inserm, "Pesticides et Effets Sur La Santé : Nouvelles Données. Collection Expertise Collective." (Montrouge: EDP Sciences, 2021), https://www.inserm.fr/wp-content/uploads/2021-07/inserm-expertisecollective-pesticides2021-rapportcomplet-0.pdf.

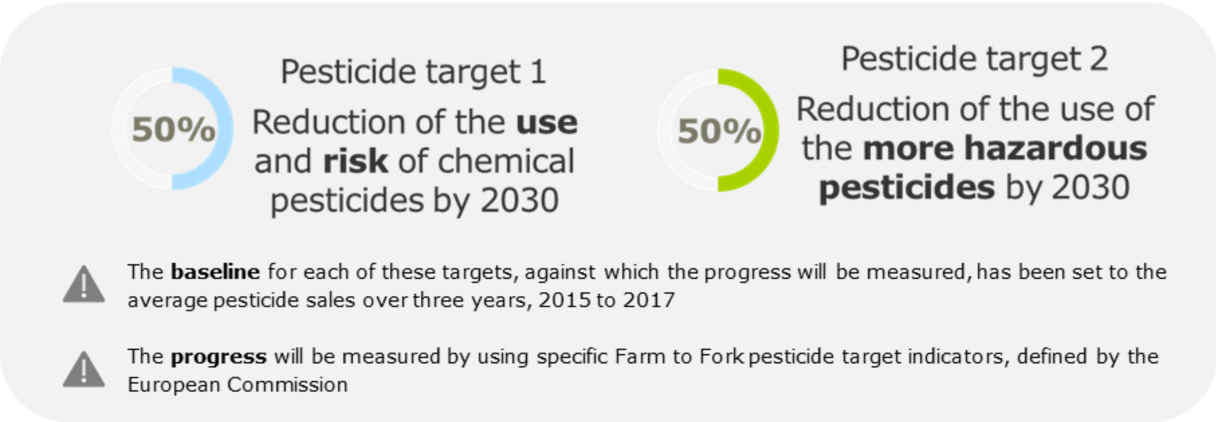
Across many of these identified diseases, evidence from academic studies[29] and EFSA annual reports arrive at similar conclusions that it is difficult to categorically link specific pesticides with increased or decreased risk to human health. Despite this, currently available data from meta-analysis by Inserm[30] points to greater links between risk of diseases and the use of herbicides and insecticides compared to other categories.

The exact impacts of pesticides on the environment and human health are difficult to assess as no indisputable indicators exist for such monitoring. Several attempts to build indicators have been conducted (e.g. HAIR research project) but such projects have not delivered the expected robust indicators which are clearly needed to assess the environmental and health impacts of pesticides.

1.3.1.3 *Recent policy developments*

In terms of recent policy development, the Green Deal through the associated F2F Strategy, announced two pesticide-related reduction targets to be met by 2030 in the EU[31].

Box 1.1 The two pesticide use and risk reduction targets of the F2F strategy[32]



On how those targets should be achieved, the F2F Strategy states the following:

> *"To pave the way to alternatives and maintain farmers' incomes, the Commission will take a number of steps. It will **revise the SUD**, enhance provisions on IPM, and promote greater use of safe alternative ways of protecting harvests from pests and diseases. IPM […] will be one of the main tools in reducing the use of, and dependency on, chemical pesticides in general, and the use of more hazardous pesticides in particular. **Agricultural practices that reduce the use of pesticides through the CAP will be of paramount importance** […]. The Commission will also facilitate the **placing on the market** of pesticides containing biological active substances and reinforce the environmental risk assessment of pesticides. […] The Commission will also propose changes to the **2009 Regulation concerning statistics** on pesticides to overcome data gaps and promote evidence-based policymaking.*

[29] Nicolopoulou-Stamati, P. et al. (2016) 'Chemical Pesticides and Human Health: The Urgent Need for a New Concept in Agriculture', Frontiers in Public Health, 4(July), pp. 1–8. doi: 10.3389/fpubh.2016.00148;

Damalas, C. A. and Eleftherohorinos, I. G. (2011) 'Pesticide exposure, safety issues, and risk assessment indicators', International Journal of Environmental Research and Public Health, 8(5), pp. 1402–1419. doi: 10.3390/ijerph8051402;

Kim, K.-H., Kabir, E. and Jahan, S. A. (2017) 'Exposure to pesticides and the associated human health effects', *Science of The Total Environment*, 575, pp. 525–535. doi: 10.1016/j.scitotenv.2016.09.009.

[30] Inserm, "Pesticides et Effets Sur La Santé : Nouvelles Données. Collection Expertise Collective."

[31] Those two targets are also restated in the "Biodiversity strategy for 2030" by the EC.

[32] https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/farm-fork-targets-progress_en

As can be seen, the strategy acknowledges that the targets are to be (and, in fact only can be) achieved through a mix of different policy instruments.

However, it should be noted that according to the European Commission the revised SUD needs to consider the policy context but should be the main vehicle for reaching the two targets.

1.3.2 Evaluation of the SUD

This study is a back-to-back evaluation and impact assessment, carried out in sequentially but within a compressed timeline which required certain aspects to be developed in parallel. The evaluation report is annexed to the present final report and the main findings by criteria are summarised as below.

In terms of **effectiveness**, there is some evidence that SUD provisions have contributed to a reduction of risk, mainly based on Harmonised Risk Indicator 1 (HRI1) which shows a decrease of 17% between the baseline period 2011-2013 and 2019 (latest available year). However, pesticide sales data show stable sales in the overall volume of pesticides in the same time period. In terms of effects on human health and the environment, the evidence is scarce and difficult to interpret or link to the SUD. Taken together, the evidence is not conclusive, and the evaluation supports previous findings that some progress in risk reduction has been made, but that the SUD has not been successful in achieving EU-wide risk and use reduction or a decrease in the dependency on pesticides. This needs to be understood against the fact that implementation of the SUD was slow to take off, in Member States (e.g., development of NAPs) and by the Commission (e.g., development of harmonised risk indicators).

The speed of implementation has increased since 2016 and although the situation is uneven among Member States, implementation appears to be picking up with application of the provisions. Enforcement of IPM remains weak as only a limited number of Member States have established appropriated monitoring systems of IPM uptake by professional users. The contribution of implementing IPM at farm level towards achieving the objectives of the SUD are largely unknown, as data is not available for large scale analysis. Therefore, the impact of the IPM requirement remains largely unclear without further steps to measure the uptake of IPM by professional users.

Efforts have been made in regards to implementation of training activities and certification of professional users (Article 5) and monitoring PAE (Article 8) and thus in harmonising practices across the EU. Results of these activities are however not fully visible as there is no indication whether the participation in a given training has led to an improvement in sustainable use or increased respect of the conditions of use of pesticides.

The costs for Member States authorities are not seen as overly burdensome, possibly also due to that several Member States had the same or similar measures in place already when the SUD was adopted[33], hence no significant additional burden was imposed. There were few indications of costs perceived as unjustified affecting other stakeholder groups, including provisions imposing costs for training and inspections on professional users of pesticides. However, given the relatively modest effectiveness of the Directive, **efficiency is considered weak** compared to the benefits generated.

The Directive is **still considered** of **high relevance** and the objectives pertinent to the issues identified at the time of adoption. Since adoption, the situation has evolved towards increasing concerns among EU consumers about the negative effects of pesticide use on human health and

[33] The number of Member States varies for the specific provisions. For instance, prior to 2011, 10 Member States had compulsory inspection systems for pesticide application equipment, 19 Member States had training systems for professional users, while 3 Member States had already adopted NAPs.

the environment, for which evidence is gradually collected and presented among the general population[34] and agricultural workers in particular[35]. Related to biodiversity loss, reports show that it is – amongst other factors – connected to the use of pesticides.[36] Insect species and in particular pollinators are found to be in decline in Europe,[37] while EU policy instruments have not been able to stop this trend[38].

The F2F Strategy and other recent EU strategies aim to address the issue with ambitions for future policies. The strategy also sets out quantitative targets for the reduction of 50% of use and risk of chemical pesticides and 50% of the most hazardous pesticides to be achieved by 2030. Other EU strategies such as the Pollinator initiative[39] call for action to halt and reverse the alarming decrease in pollinators (and other insects), with intensive agriculture identified as one of the pressures driving the decline (loss of habitat, use of pesticides), together with environmental pollution, climate change and invasive species. The Biodiversity Strategy 2030[40] highlights the urgent need to address pressures on biodiversity, to restore vital ecosystems currently being depleted by human activities.

Overall, the Directive is **internally coherent** for the majority of its provisions. However, the inability to adequately measure developments proves to be a weakness to achieving the objectives of the SUD. The SUD is part of a broad set of EU policy instruments regulating pesticides. The **external coherence** with most EU legislation was assessed positively, with some exceptions. The main criticism from stakeholders[41] on coherence also relates to the links with the CAP. Excluding key elements of the SUD (such as IPM from the requirements for obtaining CAP funding) is a weakness as it does not support the enforcement and potential data collection on this aspect, where enforcement is found to be lacking (see above under effectiveness). The CAP Post 2020 intends to address these issues with the introduction of four articles (Article 5(2) on training, Article 6 on recycling containers, Article 8 on inspection of equipment in use, and Article 13 on reduction of use in sensitive areas) of the SUD under conditionality and the opportunity for Member States to include additional measures supporting the further development and uptake of IPM under the eco-scheme (Pillar I), agro-environmental measures (Pillar II) and investment funding schemes.

The evaluation found an **EU added value** of the SUD in comparison to national or regional initiatives. Even though several Member States had measures in place already, the Directive supported further harmonisation (e.g. training, monitoring of equipment, and therefore improves respect of conditions of use) across the EU and contributed to a higher awareness of the risks inherent to pesticide use. The balance struck by the SUD is adapted to the extent that national

[34] HBM4EU (2020). Prioritised substance group: Pesticides. https://www.hbm4eu.eu/wp-content/uploads/2021/02/HBM4EU_AD5.4_Reporting_first_and_second_set_substances_v1.1-1-Pesticides.pdf

[35] Patel S. and Sangeeta S., (2019), "Pesticides as the Drivers of Neuropsychotic Diseases, Cancers, and Teratogenicity among Agro-Workers as Well as General Public"; Antonio F. Hernández et al., "Biomonitoring of Common Organophosphate Metabolites in Hair and Urine of Children from an Agricultural Community," *Environment International* 131, no. March (2019): 104997, https://doi.org/10.1016/j.envint.2019.104997. who are S+S ?

[36] OECD (2020). Managing the Biodiversity Impacts of Fertiliser and Pesticide Use. https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2020)2&docLanguage=En

[37] See for example: Potts S., Biesmeijer K., Bommarco R., Breeze T., Carvalheiro L., Franzén M., González-Varo J.P. et al., *STATUS and TRENDS of EUROPEAN POLLINATORS*.

[38] European Court of Auditors (2020). Special report 15/2020: Protection of wild pollinators in the European Union - Commission initiatives have not borne fruit

[39] European Commission (2018): EU Pollinators Initiative. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0395&from=EN

[40] European Commission (2020): EU Biodiversity Strategy for 2030 - Bringing nature back into our lives. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0380&from=EN

[41] Stakeholders related to environmental concerns such as NGOs, research and also four Member State authorities, not agricultural users

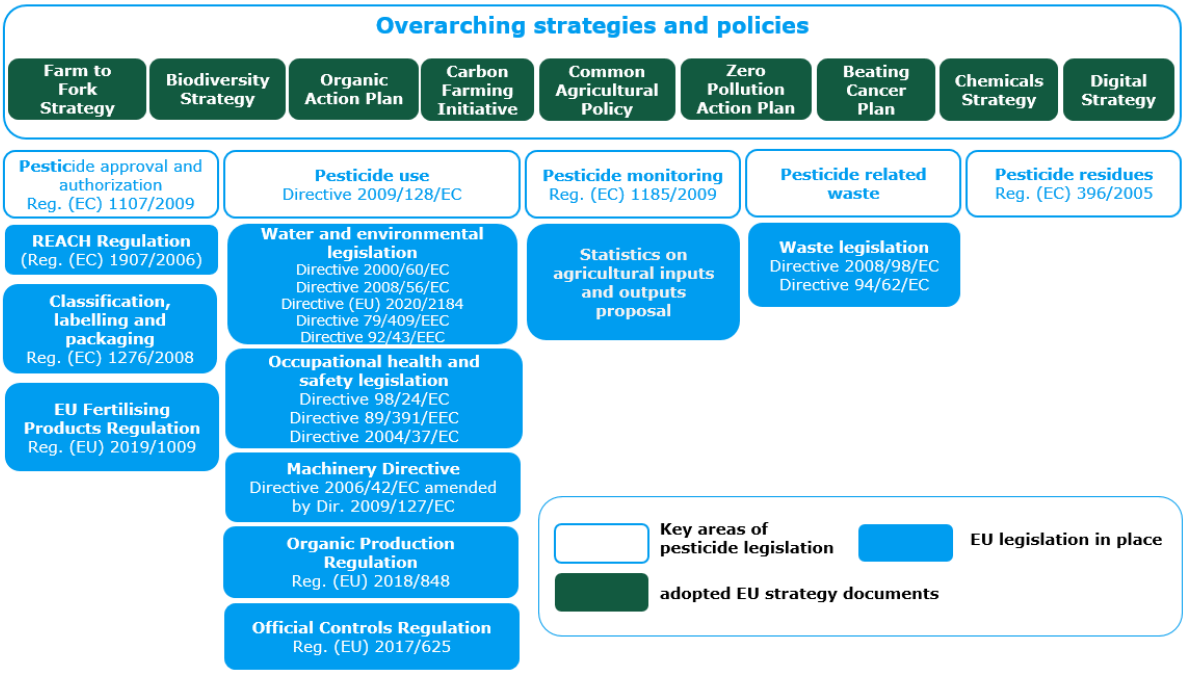
and regional particularities can be reflected in the implementation by Member States. However, this has also led to significant differences between Member States in the ambition and enforcement of implementation. Therefore, stronger oversight by the EU Commission is necessary to ensure that an effective and overall harmonised level of implementation is achieved. This is needed to reach a sustainable use of pesticides across the EU and create comparable measures for all stakeholders in the EU's single market.

1.3.3 Policy context

The revision of the SUD takes place in a context of several highly relevant strategies and pieces of legislations at the EU level. Figure 1.2 presents the key documents that form the policy context of the SUD.

Many of the legislative documents mentioned in the figure interact with the SUD on a more detailed level. The coherence with these instruments is discussed in the evaluation of coherence of the SUD in the accompanying document. The key elements of the policy context are described below.

Figure 1.2 EU policy context of the Sustainable Use Directive



EU strategies

Following the presentation of the European Green Deal[42] as its central vision for a sustainable EU economy, the European Commission has adopted several strategies for which pesticide use is relevant. These set the scene for the future of the food system, protection of biodiversity, organic production and pollution in general. In more detail, the following strategies shape the policy context:

[42] European Commission, "The European Green Deal," *European Commission*, vol. COM(2019), 2019, https://doi.org/10.1017/CBO9781107415324.004.

The **F2F Strategy**[43] presents a framework for a sustainable food system in Europe ranging from food production to consumption and waste prevention together with a roadmap of key regulatory and non-regulatory initiatives. Crucially, it sets two reduction targets for the use and risk of chemical pesticides for 2030. The two targets are presented in appendix 1. The first is an overall target of 50% reduction in the use and risk of chemical pesticides[44], while the second one aims at halving the use of more hazardous pesticides[45]. Both these targets are measured against individual baselines of the average of the years 2015-2017. The strategy also sets targets for organic farming on 25% of the agricultural area in 2030.

The reduction targets of the F2F Strategy are further mentioned and detailed in the action plans on **Organic Production**[46] and **Towards Zero Pollution**[47].

The **Biodiversity Strategy**[48] specifies the EU Green Deal in the area of conservation and restoration of healthy and resilient ecosystems, habitats and species. Key considerations are the greening of urban and peri-urban areas and reducing pollution of environmental compartments. In addition to the targets from the F2F Strategy and with an objective to reverse the declining trend in pollinators, the Biodiversity Strategy aims to reach 10% of agricultural areas in high-diversity landscape features[49], and to eliminate the use of pesticides in sensitive areas such as urban green areas.

EU pesticides legislation

The SUD is part of the EU pesticide legislation with four elements addressing different steps of the pesticide lifecycle. They are presented in Figure 1.3. Besides the SUD, these are the following pieces of legislation.

Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market represents the first step in the chain. This Regulation defines the process and requirements for active substances to be approved at the EU level and creates the framework for the authorisation of pesticides at the Member State level. Under this Regulation, the hazard profile of active substances and subsequently of pesticides are defined.

The **SUD, Directive 2009/128/EC**, sets rules for the use phase of pesticides that Member States must implement nationally in order to contribute to the objective of reducing the risks and impacts associated with pesticide use and decrease the dependency on pesticides through implementation of IPM. As a key instrument, IPM principles are defined in the Directive and made binding for professional users.

In order to underpin the pesticide consumption in the EU's Member States with data, **Regulation (EC) No 1185/2009** requires Member States to collect and share data on the amounts of pesticides placed on the market yearly, and the amounts of pesticides used in agriculture every

[43] European Commission, "A Farm to Fork Strategy for a Fair, Healthy and Environmentally-Friendly Food System," 2020.

[44] All pesticides falling under Regulation (EC) 1107/2009, except microorganism

[45] Defined in footnote 13 of the Farm to Fork Strategy as active substances classified as candidates of substitution or subject to cut-off criteria.

[46] European Commission, "Action Plan for the Development of Organic Production" (European Commission, 2021), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0141R%2801%29.

[47] European Commission, "Pathway to a Healthy Planet for All. EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'" (European Commission, 2021), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0400&qid=1623311742827.

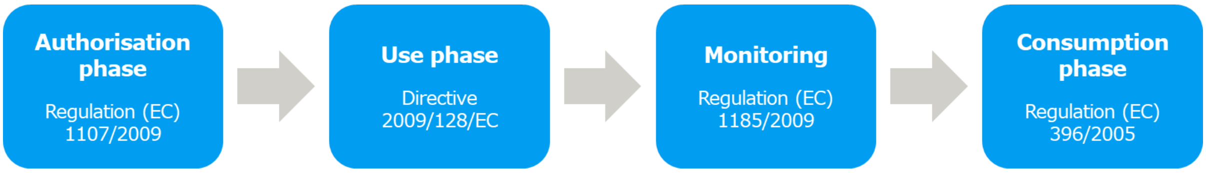
[48] European Commission, "EU Biodiversity Strategy for 2030.," vol. COM(2020), 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0380&from=EN.

[49] For example ponds, hedge rows, buffer strips or fallow land.

five years. The data can be subject to confidentiality provisions and thus not publicly accessible or analysable.

Finally, **Regulation (EC) No 396/2005** is the main legal act governing the consumption phase of pesticides. It establishes the rules for the setting maximum residue levels (MRLs) for pesticides to be found in food and feed products at European level as well as reviewing the residues found.

Figure 1.3 The regulatory lifecycle of pesticides in the EU



EU agricultural policy

Agricultural policy is a key area of EU competency and accounts for a major share of the EU's budget. The Common Agricultural Policy (CAP)[50] is the instrument regulating this area in seven-year cycles. One such cycle is currently terminating and a new CAP for which an agreement has been reached is coming into force as of January 2023.

The previous CAP did not include the SUD in its list of legislation which needs to be complied with in order to have access to CAP subsidies (cross-compliance).[51]. As the implementation of IPM and other elements of the SUD is legally binding in the EU, these could not benefit from special support for non-mandatory activities in the field of nature protection (greening).

The new CAP was adopted in December 2021, with a range of provisions of the current SUD now included in the conditionality to receive CAP payments[52]. As the CAP shapes the development of the EU's agriculture until 2027 to a significant degree, it represents an important contextual factor. Looking into the future, the expectations need to be considered in the baseline and will be discussed in Section 5.1.1.2.

Further, improvements on the availability of agricultural statistics are in progress, as a proposal for Statistics on Agricultural Input and Output (SAIO) is in negotiation. The Regulation, once in force, can be expected to create substantial synergies with the efforts to reduce the risk and use of pesticides, a key agricultural input.

1.3.4 Stakeholder landscape

Considering the diverse and complex range of issues related to pesticide use in the food system and other sectors, the stakeholder landscape is understandably large, complex and diverging. Notwithstanding this, the inclusion of stakeholder views into the IA of a future SUD is crucial.

The stakeholder landscape can be understood broadly in two categories: [1] directly impacted by the SUD and [2] in-directly impacted by the SUD. With regards to the former, the key stakeholders which are directly impacted by the revision of the SUD include:

[50] Regulations (EU) Nos. 1306/2013, 1307/2013, 1308/2013

[51] European Commission, "On Member State National Action Plans and on Progress in the Implementation of Directive 2009/128/EC on the Sustainable Use of Pesticides," 2017, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52017DC0587&from=EN.

[52] Notably, implementation of IPM at farm level remains outside of CAP conditionality.

- **Policymakers and enforcing authorities**: EU level institutions, international institutions and Member State Authorities;
- **Pesticides-related companies and services**: PPP manufacturers and suppliers, pesticide advisors, manufacturers of PPP application equipment, distributors and retailers of PPP, businesses or institutions responsible for the certification, maintenance and inspection of PPP application equipment, training and service institutions, innovators (e.g. breeders of resistant crops, developers of alternative pest control techniques (e.g. physical or biological)); and
- **Users of pesticides**: Professional users of pesticides (i.e. farmers, horticulturists, contractors, users in rail, highway and airport infrastructure, municipal authorities) and non-professional users of PPP (i.e. domestic users in gardens and small-scale horticulture).

These groups arguably are the most directly impacted by the future revisions of the SUD given the extent to which their involvement in the use or regulation of pesticides is intertwined with almost all aspects of proposed policy options. By contrast, in-directly impacted stakeholders can be understood as being impacted from either the broader implications of the SUD or by very specific provisions. The in-directly impacted stakeholders include:

- **Producers and traders**: Handlers of agricultural produce, intermediaries, and enablers of food commodities (i.e. cooperatives, small and medium sized enterprises and transnational corporations;
- **Food and beverage companies:** Primary and secondary+ processors;
- **Distributors and retailers:** Retailers, wholesalers, restaurants and catering services;
- **Society:** Food consumers, general public; and
- **Third countries:** Farmers, processing companies, traders, importers and exporters, food and beverage distributors and retailers.

1.3.5 Governance of the SUD

The Directive is a transversal policy that spans economic, social, health and environmental fields as well as a broad range of different levels of governance and stakeholders. Several Member States had their own legislation in place and based on the historic aspects of legislation and differences in governance between Member States, implementation of the SUD differs between Member States. How Member States have anchored implementation of the SUD and possible inter-institutional and inter-organisational cooperation and the level of cooperation at different governance levels varies strongly.

The European Commission, DG SANTE is responsible for the EU policy on pesticides, including the SUD. However, the SUD was developed and adopted under the responsibility of DG ENV and subsequently moved to DG SANTE in 2012, and then also within SANTE between units to the current responsibility as part of "Plants and Organics". It is within the policy responsibility of the current unit in DG SANTE (F3) since 2016. The coordination of activities related to the SUD is supported by the SUD Working Group, which includes all Member States' competent authorities, as well as DG AGRI and DG ENV, normally meeting twice a year to discuss SUD implementation and share experiences.

Within the Member States, responsibilities can be further differentiated between different authority bodies as well as regional and local authorities. At Member State level responsibilities lie with different institutions such as the agricultural or environmental ministries, which in turn can possibly have effects on the type of implementation and enforcement that is achieved within a given country.

In most Member States the implementation of the SUD is led by the Ministry of Agriculture, Food and Forestry (e.g. Luxembourg, Italy, Germany, etc.), but with varying levels of involvement of the Ministries of Environment and/or Health. In a few cases, it is led by the Ministry of Environment

(Denmark) or the Safety and Chemicals Agency (Finland). Additionally, fragmentation of responsibilities relating to the enforcement are in some cases divided between the federal and regional level (e.g. in Germany and Austria the federal levels are responsible for implementation and enforcement of several provisions). In the remaining Member States, enforcement is regularly overseen by the implementing authority. These different approaches and distribution of responsibilities brings a need for close cooperation for effective implementation. Evaluation findings has shown that this is a challenge both at the level of the Commission and Member States, due to high workloads and institutional structures.

2. What is the problem and why is it a problem?

2.1 Introduction

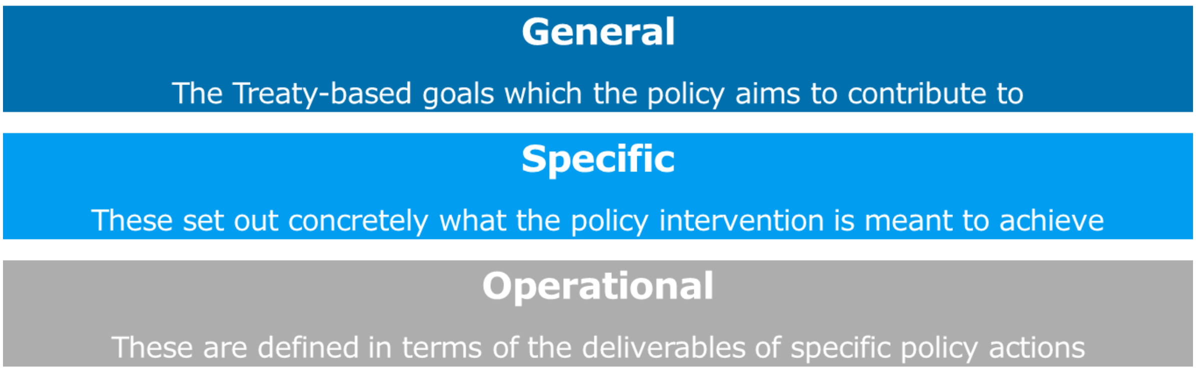
This chapter lays out the problems that a potential revision of the SUD would address. As per the Better Regulation Guidelines, the crux of any IA is on the development of a clear problem definition. Crucially it is important to explore three foundational areas, including [1] the verification of the existence of a problem and who is affected, [2] estimation of the problem's size and scale and analyse and its underlying causes and consequences and finally [3] identify the EU-dimension and assess the likelihood that the problem will persist. The problems which are discussed below will therefore seek to examine these elements where possible, through drawing evidence from the evaluation study and stakeholder consultations.

To structure the differing problems that we uncovered during the evaluation and consultations with the EC and Member States, four main categories of problems were identified, including:

1. Uneven implementation of current SUD provisions;
2. Monitoring and data availability are limited;
3. The SUD does not reflect the ambition of the Farm to Fork Strategy; and
4. New technologies are not sufficiently taken up by pesticide users.

This chapter also presents for each of the problem field the specific objectives that are derived from the problems. The figure below depicts the different types of objectives of a legislative instrument like the SUD and the place of the specific objectives in it.

Figure 2.1. Different levels of objectives



The Better Regulation Toolbox advises that general objectives are set before more specific ones are formulated. The general objectives of the SUD have already been defined when the SUD was originally put in place and are not intended to be changed. Therefore, the study proceeded directly to the formulation of specific objectives.

It should be noted that the problem definitions, drivers and objectives are presented in a high-level narrative in this chapter, given the complexity of different drivers, problems and objectives per problem field.

2.2 Problem tree

A problem tree is a graphical representation of a problem analysis which operates with the aim to find solutions by mapping out the anatomy of cause and effect around an issue. The problem tree is comprised of three main elements:

- **Drivers** - the main underlying causes of the problem which have an impact on the magnitude and scope of the problem at large.
- **Problems** – the core issues which hinder or have an impact on a matter or situation.
- **Effects** - the change which is a result or consequence of an action or other cause.

The problem analysis is based on evaluation findings stemming from literature review and stakeholder consultations, as well as discussions with the European Commission, DG SANTE. Crucially, the problem analysis examines the core "problems" relating to the workings of the SUD since its inception in 2011, rather than delving into the broader contextual problems of pesticide use across the EU (see Section 1.2.3 for more contextual information). Linking specific and isolated problems with the SUD is challenging given the complexity of the policy field and the interconnectedness of many of the problems.

In addition, while examining the main problems, drivers and effects of the SUD, there are a number of contextual points which should be considered. Firstly, many of the problems which were identified with the SUD are also impacted by other pieces of EU legislation, such as Regulation (EC) No 1107/2009 on the placing of plant protection products on the market. Despite this, the SUD regulates the use phase of the pesticides, and thus the problem analysis has mainly focussed on identifying the key problems and drivers which can be reasonably included in the scope of revised SUD. The current SUD covers all sectors where pesticides are used for crop protection, in agriculture but also professional use on roads and in public spaces such as parks, sport arenas, golf courses as well as private gardens of non-professional pesticide users.

It should also be noted that data on the use of pesticides at the EU level is limited and does not provide, an appropriate evidence base in which to accurately estimate how much pesticides are being used in different sectors. While EU level data is lacking, data at the level of Member States is available in part. However, there is a need for more systematic collection of existing data from farmers to Member States at the granular level and their transfer and aggregation at EU level. Despite this, the prevalent assumption is that application within agricultural production represents by far the largest share in all Member States (about 90%) and consequently the problem analysis is mainly focussed on the risk of pesticides in agriculture.

In terms of effects, it should be noted that the current Harmonised Risk Indicator 1 (HRI 1)[53] developed by the European Commission outlines a steady reduction in the level of risk across Member States of 21% since the baseline period in 2011-2013. In this respect, the SUD could be said to have contributed to the reduction in the risk to human health and the environment from pesticides in the European Union in the period from 2011 to 2019. It should be caveated however, that Regulation (EC) No. 1107/2009 also plays an important role in reaching the F2F targets, principally on whether active substances are (re-)approved or not. However, the contribution of the PPP Regulation in achieving the F2F targets is unknown due to the unpredictability of the outcomes of the renewal of approval of active substances process.

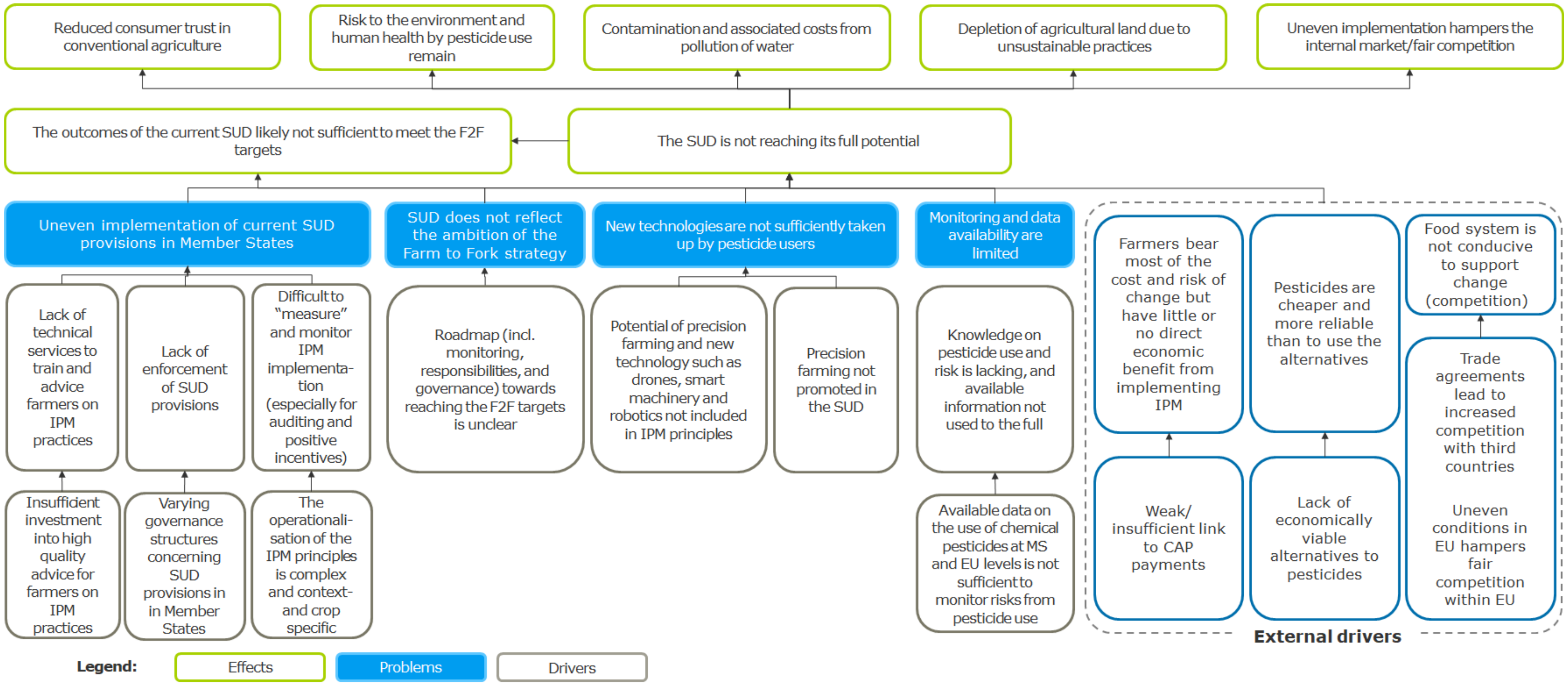
The figure overleaf presents the problem analysis tree.

Finally, another contextual factor is the further development and use of varieties resistant to pests and diseases, which is seen as a main opportunity for the application within the IPM framework and consequently reducing use of pesticides. A large number of cultivars already carry traits of

[53] Harmonised risk indicators were developed by the European Commission under Commission Directive (EU) 2019/782 in 2019 to estimate the trends in risk from pesticide use. As such, to gather data to support this indicator, Member States are obliged to calculate the Harmonised Risk Indicators at the national level, identify trends in the use of certain active substances, identify priority items, such as active substances, crops, regions, or practices that require particular attention, or good practices that can be used as examples and communicate the results of these evaluations. More information provided at: https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/harmonised-risk-indicators_en

disease or pest resistance. Such varieties may have negative characteristics (lower yield, lower quality) that lead to limited cultivation by farmers. For many stakeholders, especially researchers, the seed industry and farmers, the so-called New Breeding Techniques (NBTs) or New Genomic Techniques (NGTs) are perceived as valuable tools to create new resistant varieties relatively quickly while not carrying-out negative characteristics. However, the development of such technologies may be limited by the negative perception of such techniques by the civil society and the opposition of environmental NGOs.

Figure 2.2 Problem tree



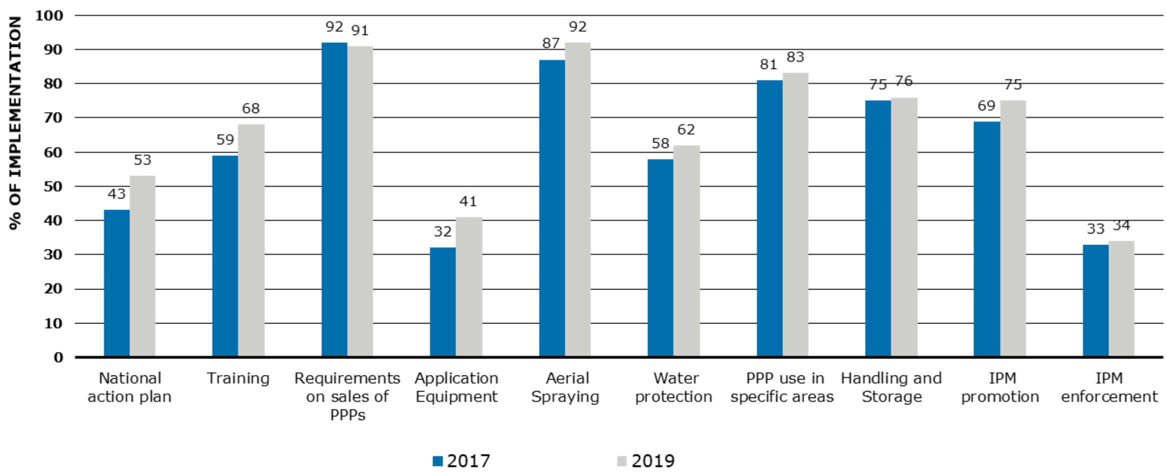
2.3 Uneven implementation of current SUD provisions

As stated in the Better Regulation Guidelines, the effective application of any EU law or piece of legislation is essential for the EU to meet its policy objectives. While Member States are responsible for the timely and accurate transposition of directives such as the SUD, it is also important for the Commission to monitor the efforts of Member States to ensure that their legislation complies with EU law. It is therefore under this context in which the crux of the problem lies. As such, this sub-section presents the definition of the problem of uneven implementation of current SUD provisions.

The verification of the existence of a problem and who is affected

In understanding this problem, it is important to understand two key parameters; [1] the factors hindering the understanding and operationalisation of the SUD provisions at the Member State level and [2] the current monitoring efforts or the lack thereof to judge the implementation of the SUD. With regards to the former, data on the percentage of implementation of selected requirements of the SUD gathered by the Commission in 2020[54] pointed to varying levels of implementation (as shown below).

Figure 2.3. Requirements of the SUD and their level of implementation



Source: European Commission (2020). COM(2020) 204 final, Annex. Available at: https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_sud_report-act_2020_annex_en.pdf

Most notably, provisions such as IPM enforcement (Article 14), pesticide application equipment (Article 9) and National Action Plans (Article 4) were shown to be lacking compared to other provisions (shown in the graph above). Given that this problem relates to most of the SUD provisions and their uneven implementation by Member States, its effects can be seen to have a wide bearing impact across all stakeholder categories and geographies.

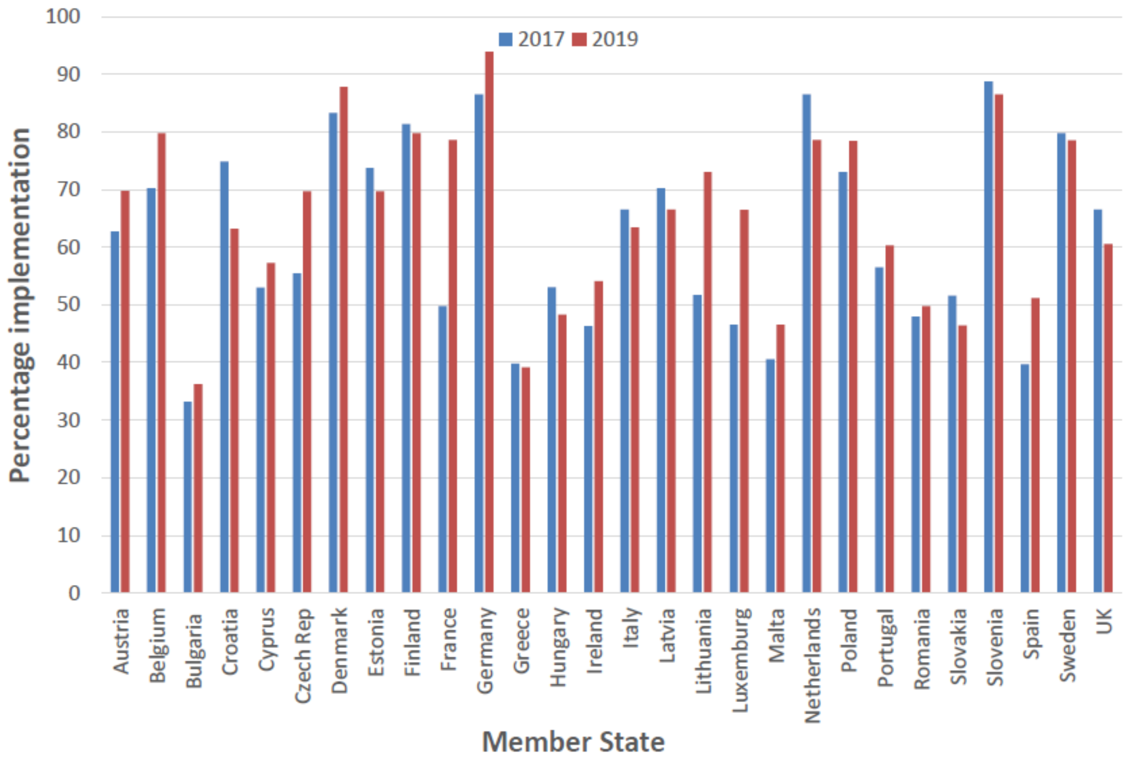
Estimation of the problem's size, scale and analysis of its underlying causes and consequences

Crucially, the 2020 review by the Commission uncovered that there was an uneven implementation of the SUD's provisions, as well as an uneven implementation across all Member States, as shown

[54] European Commission (2020). Report from the Commission to the European Parliament and the Council on the experience gained by Member States on the implementation of national targets established in their National Action Plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides.

in the figure below. This uneven distribution has an important bearing on the SUD's ability to reach its objectives and create lasting change, a point which has increased credence given the introduction of the F2F targets (see Box 1.1).

Figure 2.4. Change in the overall level of implementation of Directive 2009/128/EC from 2017 to 2019 in each Member State



Source: European Commission (2020). Annex to the report from the commission to the European Parliament and to the Council on the experience gained by the Member States on the implementation of national targets established in their National Action Plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides

Another driver which was uncovered during the evaluation of the SUD was the lack of enforcement of the SUD more generally, coupled with a lack of ambition from Member States to implement the SUD fully. Further underlying causes for the uneven implementation across Member States was found to be to the variations in governance structures of Member State authorities. As discussed in the evaluation case studies, in many countries, competences are dispersed between different ministries, national agencies or federal and regional level. This impacts the ability to collect data, create consistent legislation and an understandable legal framework for pesticide use in combination with protection of water quality, biodiversity and human health and subsequently also impacts the enforcement of the SUD's provisions.

This variation between and within Member States is emphasised no more so than under the provision of National Action Plans (NAPs) under Article 4 of the SUD. NAPs were found to vary greatly in terms of explanations of how Member States planned to concretely implement provisions of the SUD. Similarly, only four Member States[55] set clear quantitative targets in their NAPs for the reduction of risk. This variation in Member State ambition and implementation further exacerbates other problems with the SUD (as discussed below) regarding the availability of monitoring

[55] Denmark, France, Germany, Luxembourg

indicators, hindering the ability to concretely establish at an EU level the degree to which there has been a reduction in risk and impacts of pesticide use across Member States.

Another central pillar to NAPs, and indeed the SUD, is Integrated Pest Management (IPM). This provision is conceived as being one of the cornerstones of the Directive in achieving a sustainable use of pesticides consistent with crop production needs. As aforementioned, this provision was found to have a high degree of implementation regarding its promotion, however enforcement was lacking. For example, the development of crop specific IPM guidelines that can help professional users in the uptake of IPM has taken place in most Member States. However, the assessment through controls and the corresponding enforcement are found to be weak[56], which creates limited evidence on the effective implementation of IPM across the EU. Evidence from the evaluation found that qualitative assessments from stakeholders pointed to agreement with this initial assessment by the Commission.

Given the importance of IPM, the lack of enforcement of this provision by Member States ultimately has a significant bearing on the overall implementation and enforcement of the SUD. One of the main hindering factors in determining the compliance of IPM is the complexity and breadth of actions that it incorporates. This is illustrated no more so than in the Commission's definition of IPM which states that:

> "IPM means the careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment"[57]

EU-dimension and assessment of the likelihood that the problem will persist.

As previously mentioned, since this problem has far-reaching implications on all aspects of the SUD, it has a strong EU dimension. This is based on the logic and evidence from the evaluation that an uneven implementation of the SUD's provisions leads to an uneven playing field for farmers across Member States and an un-harmonised approach in reaching the SUD's objective to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management and of alternative approaches or techniques such as non-chemical alternatives to pesticides. Because of this, the level of risk reduction for health and environment varies across the EU. This is not to say that the SUD has not made progress with regards to all its provisions and contributed to reducing the risk and impacts of pesticide use, but rather it contributes to the overarching problem of the SUD not reaching its full potential.

On the basis of the evidence from the evaluation and the discussion above, as the situation currently stands, following 10 years since the entry into force of the SUD and limited progress in the last two years, there is no indication that the problem would not persist following a no-change policy decision.

[56] European Parliamentary Research Service (2018). Directive 2009/128/EC on the sustainable use of pesticides
European Court of Auditors (2020). Sustainable use of plant protection products: limited progress in measuring and reducing risks Online: https://www.eca.europa.eu/Lists/ECADocuments/SR20_05/SR_Pesticides_EN.pdf

[57] European Commission (2021). Integrated Pest Management (IPM). Available at: https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/integrated-pest-management-ipm_en

2.4 Monitoring and data availability are limited

As described in the Better Regulation Guidelines,[58] good implementation of a piece of legislation also involves the monitoring of the application of legislation on the ground. This is to ensure that the intervention performs as intended and to provide information so that corrective action can be taken if it is not performing or if there have been unintended consequences etc. The need for better performance monitoring is recognised in the Interinstitutional Agreement on Better Law-Making[59] which sets out the need to consider systematically monitoring and evaluation clauses for new EU legislation.

The verification of the existence of a problem and who is affected

Following on from the discussion on the uneven implementation of current SUD provisions discussed in the above section, an overarching problem that has an impact more generally is the lack of available data on the use of pesticides at Member State and EU levels. At present, the SUD relies on the use of Harmonised Risk Indicators (primarily HRI 1) and national specific indicators. HRI1 works by multiplying the quantities of active substances placed on the market in plant protection products by a weighting factor. While HRI 1 presents an overall decreasing trend, it does not specifically show the progress made (particularly by the SUD) in reducing the risk in specific areas.

The lack of monitoring data and corresponding reliable risk indicators proves to be a problem for almost all stakeholders, as the risk reduction efforts made by professional users cannot be quantified with accurate data, because the risk arising from use practices cannot be established. On the other hand, consistent data proving the urgency of action to reduce risk and use as formulated by environmental groups cannot be provided either. Policymakers face challenges in policy design as evidence of effects of current provisions and best practices is limited or not harmonised. Thus, for Member States there is a need for a clear legal framework for gathering data on the use of pesticides along with improvements in monitoring, which would also improve transparency for EU citizens and the evidence base for policy making.

Estimation of the problem's size, scale and analysis of its underlying causes and consequences

The use of pesticides (e.g. place, time, way of application) are not available at the EU level. The same applies to the main environmental and human health criteria, for example, poisonings caused by pesticides, on which data are insufficient. The Commission has made several attempts over the years to establish the collection of data at the Member State level on the use of pesticides in agriculture, however the currently available data are sparse both across time and geographies, thus making the use of the data impractical.

Limitations on pesticide use data primarily arise from the lack of systematic data transfer of use records kept by farmers between the farmers and the Member States and the EU and Member States; as well as from the lack of harmonisation in the aggregated dataset that would allow an analysis of trends overtime at the EU level. Evidence from the evaluation of the SUD highlighted a lack of use data being collected at Member State level in tandem with the limitations with regards to Regulation (EC) No 1185/2009 on statistics on pesticides sales[60]. Thus, the issue is not necessarily the need for *new* data on pesticide use but rather the need for a more systematic

[58] p.43

[59] Official Journal of the European Union (2016). Interinstitutional Agreement between the European Parliament, the Council of the European Union and the European Commission on Better Law-Making.

[60] For example, Regulation (EG) 1107/2009 requires the recording of pesticide application but no collection of this data a aggregated levels in the collection of statistics on pesticides under Regulation (EG) 1185/2009..

collection of existing data from farmers to Member States at the granular level and their transfer and aggregation at EU level.

Under Article 67 on Regulation (EC) No 1107/2009, professional users are required to keep records on pesticide applications, however the process is not automated, and in most Member States these records are not collected in a central database. This is linked to the fact that Article 67 of Regulation (EC) No 1107/20092009sets the provisions for record keeping but does not set the requirement for the collation of data at the Member State level. It can also be the case that there is a reluctance from some farmers to provide such data, as mentioned in one Farmers' organisation interview. More specifically they highlighted their concerns on how this data would be used, and who shall "own" such data.

Currently, pesticide use statistics are based on surveys, which are cost-intensive[61], and cover various shares of the total pesticide use, as the Members States can choose the crops the they target in the statistical surveys. These data thus cover only part of the sales to the agricultural sector.

EU-dimension and assessment of the likelihood that the problem will persist.

The prevalence of the lack of monitoring and data availability, as alluded to above, operates across the EU with only a small number of Member States providing data that can be used to accurately monitor the risks imposed through the use of pesticides[62]. Requirement for data collection and analysis at Member State and EU level have not been in place so far. On this basis, the EU dimension is high. Similarly, given that the problem has been prevalent throughout the duration of the SUD since its inception, there is little evidence to suggest that this problem would cease to persist following a no-change policy decision.

2.5 The SUD might not reflect the ambition of the Farm to Fork Strategy

As described in earlier sections, crop protection in the EU involves the use of pesticides. Around 360,000 tonnes of active substances, of which the majority are chemicals, are being used in the EU every year. Since 2011, the total quantity of sales of pesticides has remained stable, but volumes of low-risk active substances have increased[63]. In addition, land use for agricultural production has remained stable with an increasing trend for organic farming (an increase of 46% between 2012 and 2019)[64].

The verification of the existence of a problem and who is affected

Since pesticides can have harmful effects on the environment and human health when conditions of use are not respected, they are strictly regulated at EU level. The F2F Strategy recognises these challenges, stating that "the use of chemical pesticides in agriculture contributes to soil, water and air pollution, biodiversity loss and can harm non-target plants, insects, birds, mammals and amphibians", and that progress has been made in the past years and then raises the ambition by stating "[…] this demonstrates a 20% decrease in risk from pesticide use in the past five years. The Commission will take additional action to reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030." The F2F Strategy mentions a

[61] Further information on these costs in included in the assessment of policy measures in Annex 2 (see Chapter 13).

[62] Denmark, France and Sweden have established specific indicators and data collection for this.

[63] No detailed statistics available as regards the volumes of low-risk active substances used.

[64] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Organic_farming_statistics#Total_organic_area

range of policy documents working together to reach those targets, but the SUD is considered to be the main vehicle for reaching them.

With regard to who is affected, the stakeholders concerned are society at large, given that environmental and health risks are present.

Estimation of the problem's size, scale and analysis of its underlying causes and consequences

Given the verification of the existence of the problem discussed above, a number of questions are raised. Firstly, the question is to what extent do the two targets raise ambition (i.e. require additional action for meeting them compared to their baseline)? Secondly, given that the SUD is one policy instrument among a wide range of policy instruments which together govern pesticide use in the EU, the question is to what extent the actions under the SUD can and should be expected to work towards the targets, and also the question of how to measure the contribution of the SUD and thus how to attribute success or failure of reaching those targets in the end to the SUD.

Thirdly, the timeline is a crucial factor and as such a further question arises on the extent to which a revised SUD could actually play a role in reaching those targets. The targets are to be reached by 2030, meaning that a judgement in 2030 on meeting them or not would need to be based on latest available data (likely only 2028 data would be the most recent annual data available in 2030 and data for 2030 would only become available in 2032), thus only leaving very limited time for action. This is reinforced by the fact that an agreement on the final text of a revised SUD will likely take time as well as potential transitional deadlines granted to Member States.

Lastly, the question can be raised (and indeed, is raised by many stakeholders) on what basis the targets have been set and to what extent they can be considered legally binding. In particular this question was raised frequently in consultations, specifically on what the Commission has considered as the impacts of implementing the targets.

The above framework and questions lead to the need to clearly define the role of this IA support study in the process and to scope the assessments that need to be done. This should also be seen in the light of the proposed policy (see Section 5.2) which give Member States the responsibility for reaching the targets while leaving room for Member States to develop their own actions for reaching those targets. Considering the difference of current ambition and enforcement of provisions, the problem concerns primarily Member States with lower level of ambition in the reduction so far. However, as the policy developments concern EU strategies, action across the entire EU are necessary.

EU-dimension and assessment of the likelihood that the problem will persist.

This problem has a strong EU-dimension given the high political priority which is placed by the European Green Deal, and specifically the F2F targets. Thus, ensuring that the SUD is aligned with the F2F targets is of great importance environmentally, economically and socially. Given that the SUD was not designed within the context of the F2F targets since its initial IA and implementation, the problem that the SUD might not reflect the ambition of the F2F Strategy will undoubtedly persist following a no-change policy decision.

2.6 New technologies are not sufficiently taken up by pesticide users

The verification of the existence of a problem and who is affected

The SUD aims at reducing the risk related to pesticide use through various measures. New and emerging technologies of pesticide application and decision support tools are often considered one option to achieve such a reduction. Examples of such technologies are precision farming[65], more efficient and precise pesticide application techniques and alternative plant protection techniques that use less or no chemical pesticides.

In the current SUD, some reference to technologies available and suitable to achieving risk reductions is made in the principles for IPM defined in Annex III of the SUD. Principles 2, 4 and 6 cover aspects that can be supported by precision farming. However, many stakeholders see a need to further promote precision farming. In interviews, representatives of the pesticide and machinery industry, as well as pesticides users stated the need to promote the adoption of precise application tools to support professional users in the reduction of risk and use. These beneficial effects are also confirmed in the focus group discussion with researchers as well as studies and reports[66]. The specific benefits of the technologies are difficult to determine and quantify, as they depend on the technology in question and the use behaviour of the farmer or other user.

Another technology of potential relevance is the use of drones for spraying pesticides. The benefits of the use of drones as spraying equipment are more strongly debated between researcher, practitioners and environmental organisations than precision farming. Input quantities may also be reduced, a point that many stakeholders[67] mention, while scientific studies on the reduction of drift and higher efficacy are scarce[68] or not concluded yet[69]. On this, the Directive makes specific reference to aerial spraying. Article 9 prohibits aerial spraying in the EU. Derogations can, however, be granted by Member States on their territory under a set of conditions described in the same article. Drones as spraying vehicles are not mentioned explicitly, but the Commission has clarified to Member States that application from drones is to be considered aerial spraying. However, in consultations on the evaluation of the current SUD, Member State authorities as well as professional users of pesticide and manufacturers of spraying equipment describe the legal framework as unclear. The evaluation also finds that this situation presents a barrier to technological developments in the area of drone spraying.

Out of other technologies for plant protection, only low-drift nozzles are specifically mentioned in the SUD. Neither the body of the Directive nor its annexes set rules or promote the uptake of new technologies. Even though the absence of any reference is not found to be a barrier to these new technologies in the evaluation, a large number of stakeholders consider the promotion of new and alternative techniques a key issue for the future development of the SUD. These views are strongly expressed in the public consultation and originate mainly from professional users, industries producing and distributing pesticides, trade unions and public authorities.

[65] The term precision farming refers to a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. In this concept, plant protection is guided by the local pressures on crops and takes place in small-scale (possibly at the level of individual plants) interventions.

[66] SM Say et al., "Adoption of Precision Agriculture Technologies in Developed and Developing Countries," *Online J. Sci.* 8, no. 1 (2018), http://tojsat.net/journals/tojsat/volumes/tojsat-volume08-i01.pdf#page=16; Jay Ram Lamichhane, "Pesticide Use and Risk Reduction in European Farming Systems with IPM: An Introduction to the Special Issue," *Crop Protection* 97 (July 1, 2017): 1–6, https://doi.org/10.1016/J.CROPRO.2017.01.017; European Parliament, "EU Policy and Legislation on Pesticides (Plant Protection Products and Biocides)," 2017, https://www.europarl.europa.eu/RegData/etudes/IDAN/2017/599428/EPRS_IDA(2017)599428_EN.pdf; European Parliament, "Precision Agriculture and the Future of Farming in Europe Scientific Foresight Study," 2016, https://doi.org/10.2861/020809.

[67] 17 interviewed stakeholders in total, representing mainly Member State authorities and pesticide users

[68] T. Anken and T. Waldburger, "Working Quality, Drift Potential and Homologation of Spraying Drones in Switzerland," in *40. GIL-Jahrestagung, Digitalisierung Für Mensch, Umwelt Und Tier.*, ed. M. Gandorfer et al. (Bonn: Gesellschaft für Informatik e.V., 2020), 25–30.

[69] See for example [Projet PulvéDrone]

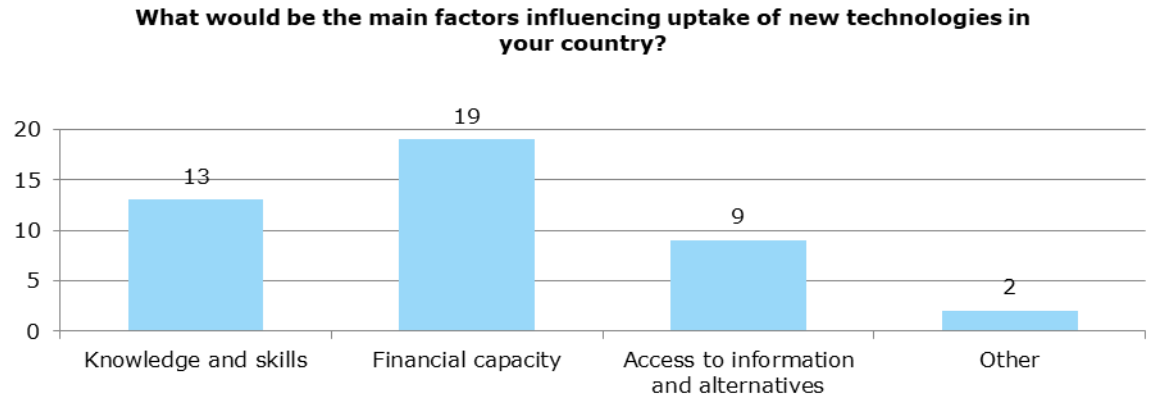
As the development, commercialization and application of new technologies are based on complex value chains, the key stakeholders affected are found in a diverse range. Developers and manufacturers of pesticide application equipment are affected by lacking legal certainty on the role of their products in the sustainable use of pesticides. Suppliers of alternatives to chemical pesticide application equipment need the same legal certainty for their technologies. Professional users, including contractors, may not be using the most effective and efficient techniques for plant protection in order to ensure yield quality and quantity due to the high costs of new technologies. Other affected stakeholders include public authorities who need to consider derogations on spraying with drones in a context of a changing technological landscape, and both citizens who may not be benefiting from the most recent technologies to reduce drift of pesticides or even large-scale pesticide application overall.

Estimation of the problem's size, scale and analysis of its underlying causes and consequences

Comparably to technology development in other economic sectors, new and emerging pesticide application technologies are driven by fast progress on horizontal technologies such as optical sensors, unmanned autonomous vehicles, artificial intelligence and telecommunication. At the moment, the resulting technologies are often expensive and therefore available to only a small share of professional users. Estimating the size and scale of the problem is however impossible, as information on farm-level use of specific technologies is not available.

The importance of the financial barrier to a higher uptake of precision farming is underlined by Member State respondents to the targeted survey and experts in the focus group on new technologies. Figure 2.5 below illustrates the survey results from Member States.

Figure 2.5 Responses from Member States authorities on the main factors impacting the uptake of new technologies (n=37)



Financial capacity is an obstacle for technology adoption on the smaller scale farms even when funding support is available. However, knowledge support and demonstration activities have been found to constitute beneficial interventions, while large farm units are the first adopters of new technologies[70].

EU-dimension and assessment of the likelihood that the problem will persist.

The development and utilisation of technologies such as precision farming – and accordingly the problems defined in this section – are expected to continue in the future. For instance, the market for unmanned autonomous vehicles (which can be used for sensing and other purposes of pest control than spraying) is found to be growing[71]. If uptake of the technologies, in particular precision farming, is not increased, the potential benefits on risk reduction remains partly untapped. In the short and medium term, the problem has a higher relevance for large and technologically advanced pesticide users across the EU because of the high initial costs. With greater affordability of the technologies, there is potential for change in this respect.

[70] Barnes A. P., Soto I., Eor V., Beck B., Balafoutis A., Sánchez B., Vangeyte J., Fountas S., van der Wal T. and Gómez-Barbero M.. Exploring the adoption of precision agricultural technologies: A cross regional study of EU farmers. Land Use Policy 80: 163–174. (2019) doi: 10.1016/j.landusepol.2018.10.004

[71] Jaime del Cerro et al., "Unmanned Aerial Vehicles in Agriculture: A Survey," *Agronomy* 11, no. 2 (2021), https://doi.org/10.3390/agronomy11020203; Ray Nishimoto, "Global Trends in the Crop Protection Industry," *J. Pestic. Sci* 44, no. 3 (2019): 1–7, https://doi.org/10.1584/jpestics.D19-101; European Parliament, "Precision Agriculture and the Future of Farming in Europe Scientific Foresight Study."

3. Why should the EU act?

The justification of the intervention is that the proposed policy options address the highlighted problems, inefficiencies and loopholes of the existing Sustainable Use Directive. The proposed revision aims to achieve better implementation regarding the legislation of pesticide use in helping to ensure a high level of protection of human health and the environment. In addition, together with other pieces of EU pesticide legislation, regulating pesticide use at the EU level contributes to coordinated and in the long term more efficient action on EU priorities and strategies leading to improved respect of internal market rules and proper functioning of the EU market for active substances and plant protection products.

Without any EU intervention, the diverging implementation in the Member States is very likely to continue, potentially leading different levels of protection of health and environment and diverging conditions for the main users of pesticides (i.e. farmers) in the Member States, which would be against one of the fundamental objectives of the Treaty of Functioning of the European Union (TFEU).

The specific nature of the intervention requires to find an equilibrium between a high level of subsidiarity as well as to be coherent with other EU pesticide legislations and the Post-2020 CAP and a level playing field.

Knowledge on pesticide use varies considerably across Member States[72], and therefore there is a need to reinforce knowledge transfer and favour exchange of information across Member States for an optimal implementation of measures that would reduce risks and impacts of pesticides.

Eventually, without any EU intervention, considering the findings of the evaluation and the problem definition above, the SUD in its current form is unlikely to achieve the ambition of the pesticide-related targets announced in the F2F Strategy without concerted action at EU level.

Even without considering the ambition of the F2F Strategy, the evaluation finds that the current situation of differing implementation within the Member States and resulting differences in effectiveness of the SUD would continue to persist in case no revisions are undertaken. Altogether, this points to a continuing need for EU level action.

3.1 Continued need for intervention due to transnational aspects

The main purpose of the SUD is to establish a framework to achieve a sustainable use of pesticides by (1) reducing the risks and impacts of pesticide use on human health and the environment and (2) promoting the use of IPM and alternatives approaches or techniques. As for most Global Food Law legislations, those aspects have a strong transitional component (e.g. from upstream/downstream relationships), which require action to be taken at EU level. This was already stated in the original proposal for the SUD[73], which acknowledged that a divergence of measures taken in Member States may lead to the perception that different levels of protection of health and environment are present and diverging conditions for the main users of pesticides, which may be against one of the fundamental objectives of the Treaty on the Functioning of the European Union. A revision of the SUD, tackling the aforementioned problems at EU level, is thus required.

[72] European Parliamentary Research Service, *Directive 2009/128/EC on the Sustainable Use of Pesticides; European Implementation Assessment*, ed. Milan Remáč (Brussels, Belgium: Ex-Post Evaluation Unit, 2018), https://www.europarl.europa.eu/RegData/etudes/STUD/2018/627113/EPRS_STU(2018)627113_EN.pdf.

[73] Commission Staff Working Paper accompanying the proposal for a Directive of the European Parliament and of the Council establishing a framework for Community action to achieve a sustainable use of pesticides

Another transitional aspect is the functioning of the internal market which would be hampered if only selected Member States would take actions to reduce the risks for health and the environment linked to pesticide use since this may lead to an uneven playing field resulting in uneven competition for pesticide users and pesticide industry. The continued use of chemical methods to control pests is linked to the multiple factors of which the overall economic pressures in the farming sector and the effectiveness and ease of use of chemical pesticides versus alternatives, with competition from within and outside the EU. While environmental organisations point to successful demonstration of alternatives, the prevalent perception among pesticide users appears to be that there is a lack of viable alternatives and that chemical pesticides are cheaper and more effective or reliable than alternative methods[74]. In addition, farmers bear compliance costs stemming from the SUD provisions (trainings, inspections of PAE, IPM uptake), while the socio-economic benefit is uncertain. In combination with uneven implementation, price pressures and competition from within and outside the EU, the drivers do not leave much room for taking the risk of changing production practices.

If Member States implement the SUD in a more harmonised way after its revision, this would lead to a more level playing field for farmers and other involved stakeholders. Farmers would need to comply with a similar set of requirements and thus costs (for example in terms of recording and reporting, the costs and time for training and certifications, negative and positive incentives such as taxes or levies, etc.).

3.2 Benefits from action at EU level

From the consultations, there was a clear agreement on the SUD's EU added value. The main benefits of EU action remain the same as for the SUD, to promote a sustainable use of pesticides across the EU, which reduces the risks to human health and the environment and to support a level playing field on the internal market.

For certain aspects, there may be a potential for economies of scale. For example, in terms of standards and norms for pesticide application equipment (PAE). Stronger harmonised norms and standards at EU level could ensure high quality training and advice in all Member States and stimulate innovation and improve the market conditions for manufacturers of PAE. Such effects of a revised SUD could ultimately lead to improvements in biodiversity, other environmental parameters and human health in comparison to the situation discussed in the context of the impact assessment (see Section 1.2.3).

The EU also possesses other key instruments in agricultural and food policies with which synergies can be created. The most relevant element in this respect is the Common Agricultural Policy (CAP), which is outside of the scope of the SUD and also outside of the direct mandate of DG SANTE, and thus not directly addressed by the potential policy options. In the agreed and adopted CAP framework, incentive mechanisms to support lower pesticide risk and use practices were reported to be weak by stakeholders and have been insufficient to stimulate a broader transformation towards more sustainable agricultural practices. The new CAP expands the list of SUD provisions in scope for the conditionality mechanism of requirements to obtain CAP support.

3.3 Subsidiarity

The problem concerns the majority of Member States, although the context varies with the type of agriculture, climate conditions and profile of farmers (age, education).

[74] Public Consultation

Intra EU trade in food products is high. In 2019 the total value of food product exports stood at 212 billion Euro. Germany was the largest exporter of food in the EU-27, its exports of EUR 40 billion were 19.3 % of total EU-27 exports to other EU-27 Member States, followed by the Netherlands, Belgium, France and Spain. There were three Member States[75] where the share of food in their total exports within the EU-27 was above 10%. Not all the trade volume is related to products on which pesticides are used. Trade in meat, egg and dairy products is only indirectly connected to pesticides through animal feed. However, the trade volume further underlines the cross-border relevance of food-related policies in the EU.

In Member States with a high share of food in their total exports, the agricultural sector will be seen as an important driver of growth, which on the one hand can lead to greater political focus and will and on another hand may lead to resistance to change (due to a perceived or real loss of competitiveness for farmers). Because of the high intra-EU trade in food products, pesticide use in one Member State has the potential to affect consumers across the EU. Use practices can therefore impact the risk for human health in a cross-border context.

If the problem(s) related to sustainable use of pesticides is left only to Member States, the current difference will remain or intensify, driven mainly by political will, the market drivers and public opinion/consumer attitudes. These will continue to differ between Member States (and between mandates), leading to different levels of protection of human health and the environment in the EU and an uneven competition on the internal market (as the rules regarding the use phase will continue to differ between Member States).

[75] These were Denmark (13%), Greece (13%) and Lithuania (13 %).

4. What should be achieved?

Following the problem definition and problem tree in Figure 2.2, the objective tree presented in Figure 4.1 overleaf illustrates the objectives to be achieved with a revised SUD.

It should be noted that the SUD and a revision of the SUD also has important implications on some of the Goals and targets of Agenda 2030 of the United Nations. Most relevant in this context are the following Sustainable Development Goals:

- SDG2 "Zero Hunger": As shown in this report there are concerns by some stakeholders that a reduction of use of pesticides could lead to a decrease of yield – however, there is no consensus on this and no conclusive data, also given the complexity of this issue. Concerning SDG target 2.1[76], within the EU, hunger (i.e. acute and/or chronic lack of nutrition) is not a large-scale problem and where it exists, it is rather linked to affordability of food than to availability of food. In case the reduction of pesticide use (and potential other factors such as increase of cost for production) would lead to an increase of prices for food, this could lead to an increase of affordability issues for low-income households with potential impacts on diets and nutrition. On the other hand, the SUD and a revision of the SUD should play a key role in reaching the target of a "sustainable food production system" as part of target 2.4.[77]
- SDG3 "Ensure healthy lives and promote well-being for all at all ages": The reduction of use and risk of use of pesticides (including exposure through spray drift and when handling pesticides, but also from consumption of food with mixture of substance residues for which risks are not well known, as well as exposure to pesticides in the environment) could lead to health benefits across the population, directly contributing to target 3.9.[78]
- SDG6 "Ensure access to water and sanitation for all": Water service providers have the objective to provide clean water to society. A reduction of pollution of pesticides in water bodies would reduce the risk of them reaching households trough the supplied drinking water. Also, in cases where pesticides are detected and cleaned from the water, this leads to increased costs for the service providers and ultimately for the users (through increased fees); this can also be prevented by reducing the use and risk of use of pesticides. Thus, the SUD and a revision of the SUD directly contributes to the objective of "safe and affordable drinking water" as part of target 6.1[79] and target 6.3.[80] This is further discussed in the introduction to section 7.4.2 of this report.
- SDG8 "Decent work and economic growth": Reducing the risk and use of pesticides, in particular the exposure from handling the substances and spray drift contributes directly to the target of ensuring safe and secure working conditions for all workers (target 8.8). Furthermore, fostering innovation and technology on food production systems contributes to target 8.2[81].

[76] By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

[77] By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

[78] By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

[79] By 2030, achieve universal and equitable access to safe and affordable drinking water for all

[80] By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

[81] Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors

- SDG11 "Sustainable cities and communities": This goal can be promoted by increasing the safety using public urban green spaces and ensure their inclusiveness to vulnerable groups. This would directly contribute to target 11.7 [82].
- SDG12 "Responsible consumption and production": improving the management of chemicals in the objective of reducing releases to air, water and soil relates to the key objectives of the SUD. A strengthened SUD would therefore ensure that target 12.4[83] is maintained and improved.
- SDG14 "Life below water": The greatest source of pollution in the seas and oceans originates on land and is transported to the seas and oceans though rivers, by air and other pathways. The direct risks to marine ecosystems are generally limited, but cases of long-term harmful effects have occurred in the past. In particular, agriculture near coasts (e.g. on islands) can result in contamination of coastal waters with negative effects on marine life and the sustainable use of resources[84]. A reduction of use and risk of use of pesticides would reduce the load of pesticides being spilled into the oceans and would thus contribute directly to target 14.1[85].
- SDG15 "Life on Land": The reduction of use and risk of use of pesticides with an accompanying change of agricultural practices (including IPM) can contribute to the conservation of terrestrial and inland freshwater ecosystems and their services and thus contribute to target 15.1.[86]

[82] By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.

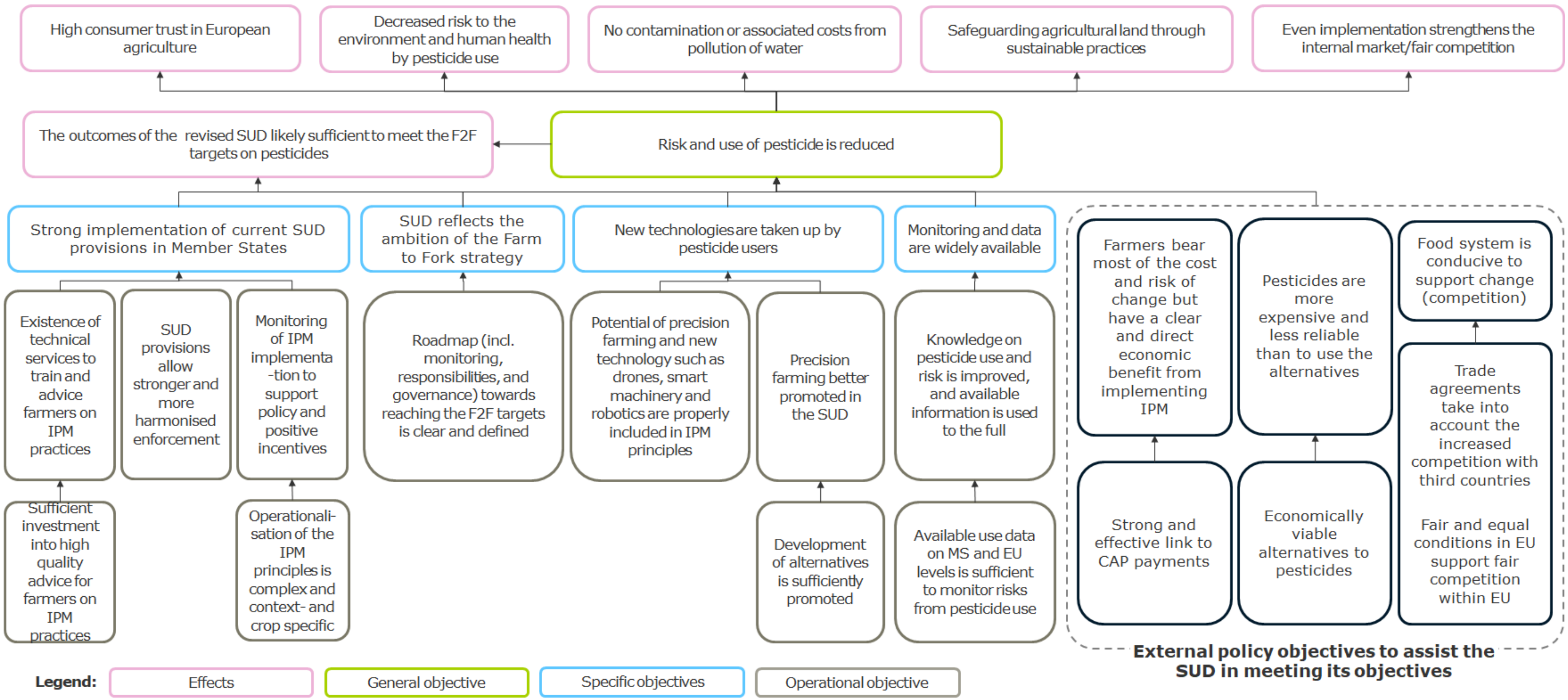
[83] By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment

[84] Jacques A Bertrand et al., "Chlordecone in the Marine Environment around the French West Indies: From Measurement to Pollution Management Decisions," *ICES-CM* 07 (2010), https://archimer.ifremer.fr/doc/00014/12511/9361.pdf.

[85] By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

[86] By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

Figure 4.1 Objective tree



5. What are the various options to achieve the objectives?

5.1 Introduction

This chapter describes the policy options being considered in the IA. It starts with a discussion of the no-change scenario, e.g. what would be likely development in relation to sustainable use of pesticides if the SUD remains unchanged. Subsequently it provides an overview of the policy options put forward by the European Commission for the IA study.

5.1 Baseline

The baseline seeks to establish what will be the likely development in a "no change scenario", e.g. where the SUD remains unchanged.

The policy space in which the SUD operates (i.e. the use phase of pesticides) can have strong environmental, social and economic impacts. At the same time, the impacts are also highly influenced by external drivers, i.e. factors which are not controlled by the SUD but which have major effects on reduced pesticide use and risk.

- First, this chapter discusses the main external drivers (policy, environmental, social and economic) that will likely influence the sustainable use of pesticides until 2030 (and beyond); and
- Secondly, the baseline assesses the likely development of identified main indicators, discussing how these indicators will likely develop until 2030, if no revisions are made to the current legislation.

The baselines for social, economic and environmental indicators used to assess the likely impact of achieving the F2F pesticide related targets are presented in Chapter 7[87], where the impacts of achieving the targets are being assessed.

5.1.1 Main external drivers

5.1.1.1 *Introduction*

The sustainable use of pesticides touches upon a broad array of fundamental economic, social and environmental aspects. However, the sustainable use of pesticides is often only one of several factors influencing those aspects.

A (sometimes large) part of the reason of how the main indicators will develop under the baseline[88] is thus also affected by external drivers, i.e. factors, which are not controlled by the SUD, but which have major effects on the policy space in which the SUD operates. It is crucial to understand the development of those external drivers which include other policy developments, environmental external drivers and social and economic drivers. They are discussed in the following sections.

5.1.1.2 *External drivers from policy developments*

The current and changing policy context described in Section 1.3.1.3 will impact the development of EU agricultural and food systems. The F2F and Biodiversity strategies, the other EU pesticide legislation as well as the CAP post-2020 are key drivers. The effect of these elements will depend on the actual implementation of the policies and the degree of achievement of the targets. For the

[87] And in more detail in Chapter 10 in Appendix 1

[88] As well as under the assumption that the two pesticide-related F2F targets are met which is assessed in Chapter 7/

consideration in this baseline, however, complete implementation across the EU and reaching the set targets is assumed.

Agricultural and food systems

The F2F Strategy, including the Organic Action Plan, set the strategic framework for the food system from production to consumption. The CAP also determines the developments to a large extent in primary production. Table 5.1 below presents the key effects of food system policies and strategies on the SUD baseline.

Table 5.1 Overview of effects by drivers from agricultural and food system policies and strategies on main indicators

Driver	Which main indicators could this affect and how
Organic production increases to 25% of agricultural area (F2F Strategy, Organic Action Plan)	• Organic farming has high restrictions on the use of synthetised pesticides. Therefore, the use of many pesticides decreases, while some (including copper, a candidate for substitution) and biocontrol products are applied at higher volumes. • Higher reliance on natural pest control and greater crop diversity and longer crop rotation cycles leading to diversification.
Action to further facilitate the registration of seed varieties is undertaken (F2F Strategy)	• Varieties adapted for organic production and with stronger resistance to environmental stress and pests require less pesticide input, which leads to decreasing indicators on pesticide use, in a medium to long term horizon (due to timeline for development of resilient varieties).
CAP agreement contains provisions for transition away from pesticide use	• The CAP agreement includes parts of the SUD provisions under conditionality as a new SMR. The outcome of the trialogue led to the adoption of four SUD measures under that SMR, of which IPM is excluded. However, IPM is not excluded from conditionality as several GAEC address IPM related issues (e.g. GAEC 8 on crop rotation).
CAP eco-schemes fund among others agro-ecology, precision agriculture (CAP)	• Funding for climate and environmentally friendly practices favours low-pesticide farming and thus reduces SUD and F2F indicators.
Adoption of a Code of Conduct for responsible business and marketing of food processors and retailers (F2F Strategy)	• Increased guidance and awareness in food processing and retail leads to pressures for producers to comply with sustainability standards. Demands for lower pesticide risk reduce indicators HRI1 and F2F1.
Continued R&D funding for agricultural research through Horizon Europe[89]	• Research in the area defined as "Agriculture, forestry and rural areas" contributes to create a broad toolbox to ensure plant health and risk management. Alternatives to chemical pesticides that are developed reduce the use of pesticides and consequently the related risk indicators.

[89] https://ec.europa.eu/info/research-and-innovation/research-area/agriculture-and-forestry/plant-health_en

Biodiversity conservation and restoration

Decreasing biodiversity and actions to reverse this trend receive high attention in current EU strategy documents like the Biodiversity Strategy for 2030[90] and the Pollinators Initiative[91]. Efforts in pursuit of biodiversity conservation and restoration have impact the context of pesticide use and some relevant indicators of the SUD baseline. These are presented in Table 5.2.

Table 5.2 Overview of effects by drivers from biodiversity policies and strategies on main indicators

Driver	Which main indicators could this affect and how
10% of agricultural area contains high-diversity landscape features (Biodiversity Strategy)	• The priority given to hedges, buffer strips, fallow land and other features reduces the area on which pesticides can be applied.
EU is stepping up efforts to protect soil fertility, reduce soil erosion and increase soil organic matter (Biodiversity Strategy)	• Soil structure and fertility will be improved. • Reducing soil erosion favours no-plough practices, which rely on pesticides for weed control and increases the use of herbicides.

Pesticide legislation

The EU pesticide legislation will continue to provide the rules for pesticide authorisations, statistics, maximum residue levels and pesticide use. In particular, the authorisation process and active substances requiring a renewal of their approval shapes the risk profile of available plant protection products. The table below summarises the baseline effects of the pesticide legislation.

Table 5-5.3 Overview of effects by drivers from pesticide policies on main indicators

Driver	Which main indicators could this affect and how
Continued (re-) approval of active substances (AIR programmes) changes the availability of pesticides in different hazard categories (Regulation (EC) No 1107/2009)	• Approving more low risk active substances, while approvals for higher hazardous active substances (CfS) is not renewed decrease the HRI 1 and F2F 1 • More emergency authorisations for substances whose approval ran out increases the HRI 1&2 as well as F2F 1 indicators.
Proposed legislation on Statistics on agricultural inputs and outputs (SAIO) will improve data availability and quality on pesticide use[92]	• Data on inputs (including pesticides) and outputs of the agricultural sector allows better understanding of pesticide use patterns.

[90] European Commission, "EU Biodiversity Strategy for 2030."

[91] European Commission, "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. EU Pollinators Initiative," 2018, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0395&from=EN.

[92] European Parliament Research Service. Statistics on agricultural inputs and outputs (SAIO): Updated rules. February 2021. https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/662607/EPRS_BRI(2021)662607_EN.pdf

Driver	Which main indicators could this affect and how
Continued application of Reg. (EC) 396/2005 on maximum residue levels	• Continued data collection on residues in consumer food products

5.1.1.3 *Environmental external drivers*

Climate change

A changing climate has several implications in the context of the SUD and will continue to do so with increasing speed in the future. However, effects will vary across climatic zones and on the adequacy of adaptation measures taken, and there is much uncertainty about the actual magnitude of the effects.

The table below lists the main climate-change related drivers.

Table 5-5.4 Overview' of effects by climate-change related drivers on main indicators

Driver	Which main indicators could this affect and how
Increase in heat stress, water stress and droughts[93]	• The drivers can lead to changes in the capacity of ecosystems to produce services, potentially leading to effects on food security and increased intensification of agriculture to meet demand. • Climate change can lead to more susceptibility of plants against diseases and pest, leading to an increased consumption of pesticides
Increase in heat and cold stress, water stress, heavy precipitation, droughts[94]	• Can lead to major shifts of ecosystem and thus in the short term (accounting for time and measures required to adapt the agricultural sector to changing conditions) lead to decrease of agricultural produce, increase in food prices and/or decrease farmer income, or effects on food security
Increase of intensity and frequency of extreme weather events leading to the destruction of crops (e.g. hail storms)	• Increased need for crop insurance might increase premiums for insurance and could thus increase food prices and/or decrease farmer income, adding pressure on producers' margins.
Acceleration of introduction and spread of invasive species[95]	• Agricultural produce of specific crops could decrease due to new pests. • Sales of active substances could increase to deal with new pests • Food prices and/or farmer income could be affected through reduced agricultural produce and need for increased sales/use of active substances • Food security could be affected through reduced agricultural produce
Indirect transboundary impacts of climate change[96]	• Food security could to some extent be affected due to climate change vulnerability in non-European countries which export to the European market

[93] See e.g. table 1.1 in EEA (2019). Climate change adaptation in the agriculture sector in Europe

[94] See footnote 93

[95] For a detailed overview on the topic see e.*g.* IPPC Secretariat (2021). Scientific review of the impact of climate change on plant pests – A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems. Rome. FAO on behalf of the IPPC Secretariat.

[96] For a detailed overview see e.g. Arvis et al. (2020). Consequences of global climate change and their impacts on Europe — a view on agricultural commodities, report for the European Environment Agency, Ramboll

5.1.1.4 *Social and economic external drivers*

Population development in the EU and worldwide[97]

World population growth, despite slowing down to 0.9% per year by 2030, will remain a key driver of demand growth. The EU population will remain almost stable (slightly lower in 2030 compared to 2020), contrary to other countries and regions. In particular, the African population is expected to sustain a strong annual growth over the period (+2.3%) and is projected to overtake the Chinese and Indian populations by 2025, reaching 1.7 billion people in 2030. As food production in Africa is unlikely to keep up, food imports into the continent are projected to continue rising. Income growth, although tempered by COVID-19, will lead to higher imports worldwide.

Development of characteristics of the farming sector

There are a number of characteristics of the farming sector which could have a bearing on the main indicators. They are listed in the table below.

Table 5-5.5 Overview of effects by characteristics of the farming sector on main indicators

Driver	Which main indicators could this affect and how
Upcoming generations of farmers tend in average to be more educated and have better grasp on technologies	• Could in general lead to improvements in all risk and environmental main indicators since IPM principles are more closely followed
Agricultural[98] land will continue to face ongoing competition from afforestation, as well as from urban areas and roads. The agricultural sector underwent significant land consolidation in the past and agricultural land has been more stable since 2015. Between 2020 and 2030, a further 0.5 million ha reduction in agricultural land is expected, taking the total to 161.2 million ha. Forest area in the EU has been steadily increasing since 2010 and gained 1 million ha in the last 5 years. It is expected that forests will continue expanding at a similar rate and could reach 161.0 million ha in 2030.	• A decrease of agricultural land could potentially lead to a decrease of agricultural produce then leading to a reduction of pesticide use as less acreage will have to be protected
Digitalisation will enable a more targeted use of pesticides along with improved management systems and decision-support tools	• This can lead to gains in a significant pesticide use reduction then a reduction in environmental and health impacts
Exchange rates are also a relevant macroeconomic driver. High exchange rates reduce the competitiveness of EU production, leading to lower exports, while a lower price of foreign products in euro would incentivise imports.	• Trade projections will be impacted by exchange rate assumptions
Supply and demand relationships are influenced by macroeconomic drivers - mainly oil prices and exchange rates (see above) but including others such as real GDP and	• There is uncertainty in commodity prices trajectories due to the underlying macroeconomic and yield uncertainty. This

[97] This section is based on European Commission (2020). EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels

[98] This section is based on European Commission (2020). EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels

Driver	Which main indicators could this affect and how
consumer price index - and yield factors. According to the EU Agricultural Outlook for Markets, Income and Environment 2020-2030[99], the crops with most uncertain yields are rye, maize, sugar beet, soya been and sunflower, although there are significant differences between Western and Central European Member States.	may influence production costs and food prices.

COVID-19

Agriculture is considered an essential sector connected to food security. While it has been impacted by the COVID-19 crisis in Europe, the immediate ramifications have been more limited e.g. compared to tourism, hospitality etc. which are still being heavily impacted. Farms are still operating; food is being produced and there have been no major disruptions in the supply chains. The drop in demand from the hospitality sector may also have had an impact on farmers, but likely more in animal production and processed high value foods (e.g. cheese). Farmers may have experienced a shortage of labour, specifically those dependent on migrant workers for harvesting of fruit and vegetables. However, several Member States have put in place schemes to mitigate the restrictions on movement. The pandemic may have spurred a movement towards buying more locally produced food, but it is uncertain whether this trend will continue and how strong it will be. It appears likely COVID-19 will continue to be a factor affecting lives and livelihoods, including farmers. It is impossible to say for how long, as this will depend on medical progress and the effectiveness of vaccines.

At the moment, impacts of the COVID-19 on the food system are uncertain and it is not possible to predict how COVID-19 may influence pesticide use.

5.1.2 *No change scenario on the main indicators*

The main indicators used for the baseline are linked to reaching the two pesticide-related F2F targets. These targets work towards the overall objective of the SUD, i.e. reducing the risks and impacts of pesticide use on human health and the environment[100], as measured against the F2F targets.

Risk of pesticide use is not further defined in the current SUD. A definition is provided for "risk indicator" which, in the context of the SUD, means "the result of a method of calculation that is used to evaluate risks of pesticides on human health and/or the environment". The SUD establishes two HRIs[101] which are used by the EC to monitor and calculate the risks associated with pesticide use and for which this chapter establishes a baseline. In addition, the F2F strategy established two indicator targets; given that a revised SUD is considered to be the main instrument to achieving those targets, this chapter also establishes a baseline for those targets.

[99] EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels

[100] It should be noted that another stated objective is "promoting the use of IPM"; however, since applying IPM is not a goal in itself but rather a means to achieving the overall goal of risk reduction, it is not specifically mentioned here in this context of the main indicators.

[101] Based on obligations of Article 15(1) of the SUD and established through Commission Directive (EU) 2019/782 of 15 May 2019 amending Directive 2009/128/EC of the European Parliament and of the Council as regards the establishment of harmonised risk indicators (Text with EEA relevance.)

In summary, this chapter establishes a baseline for the following risk-related indicators:

- HRI1 and F2F target 1 based on sales of pesticides (assessed together, given that F2F target 1 uses a slightly modified HRI1 for measurement);
- HRI2 based on emergency authorisations; and
- F2F target 2 based on sales of more hazardous pesticides.

In this context, it is important to emphasise that a reduction of the use of pesticides is not a stated objective of the current SUD. The F2F target 2 is the first and only European indicator directly aiming at a use reduction. The provisions in the current SUD aim to reduce risks and impacts related to health and environment from pesticide use, which may be associated to a certain pesticide use reduction as a consequence. Moving to a more sustainable use of pesticides may also lead to a shift from more to less hazardous pesticides. This may require higher volumes or more targeted treatments, which would consequently have an increased use (but with a lower risk).

5.1.2.1 *Development of HRI1 and F2F target 1 indicator*

HRI 1 measuring the risk of pesticides, shows a decrease in 2019 of 21% since the baseline period in 2011-2013, with a decrease of 4% between 2018 and 2019[102]. The change is mainly driven by an increase in the use of low-risk pesticides (Group 1) and a decrease in the use of non-approved pesticides (Group 4) and to a lesser extent the more hazardous pesticides (CfS, Group 3).

The F2F 1 indicator of 50% use and risk reduction of chemical pesticides will be measured using the HRI1 methodology, but excluding micro-organisms (viruses, bacteria, etc) and using a different baseline. As with HRI 1, the indicator is an index, with a baseline set as average sales 2015-2017. Hence, it is not built on absolute values or kg of sales, rather the change observed in each Member State, with weightings applied to the different groups of active substances. The Commission has published guidance to Member States for the calculation of F2F 1[103], including an updated annex on classification of active substances into groups according to their hazardous properties (same as HRI1 classification). The trend calculated with this methodology shows a decrease of 13% in 2019 at overall EU level, from the baseline period 2015-2017, with strong variations between Member States[104].

Different factors other than the SUD drive the development of the HRI 1 and F2F 1 indicators. A key factor is the renewal or non-renewal of approved active substances, and in particular the more hazardous substances (Candidates for Substitution, Group 3). When an active substance is non-approved (Group 4), the users must find an alternative method (PPP or non-PPP) to control the relevant pest. According to the pesticide database[105], as of 10 September 2021, a total of 33 candidates for substitution (CfS) have not been approved for renewal, which corresponds to 43% of the original list of candidates for substitution established in 2015[106]. Currently, candidates for substitution (Group 3) contain 58 approved active substances. This list is likely to evolve, as all CfS will have to be re-evaluated for renewal before 2030. Active substances currently in other groups may be added to the CfS list as the outcome of their renewal process. In conclusion, the approval process for active substances will strongly influence the development of HRI 1. Given that the outcomes of the renewal process for CfS are not possible to predict, and that no granular sales data

[102] https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/harmonised-risk-indicators/trends-eu_en

[103] Available at https://ec.europa.eu/eurostat/web/agriculture/agri-environmental-indicators/information

[104] https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/farm-fork-targets-progress_en

[105] Accessed 13/09/2021 https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/active-substances/?event=search.as

[106] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R0408&rid=1

per active substance is publicly available, it is not possible to estimate different scenarios in terms of renewal/non-renewals and what the likely impact could be on the HRI and F2F indicators.

With no change to the SUD, the F2F pesticide targets would mainly rely on current pesticide package policy provisions and other related policies which can have an influence on reaching the targets, such as an increase in organic farming (in line with F2F targets). However, an increase in organic farming may lead to increased use of biocontrol products and copper compounds (candidates for substitution, authorised in organic agriculture as a bactericide and fungicide[107]), which could offset the expected decreased use of other chemical pesticides resulting from the switch to organic production.

Taken together, it may be that the F2F targets of 50% reduction in risk and use of chemical pesticides is achievable without any change to SUD, since the risk reduction is driven by other factors, most notably Regulation (EC) No 1107/2009 and the potential non-(re) approval of active substances classified as candidates for substitution. Still, the relatively short timeline until 2030[108], means it is unlikely to be met without stronger and concerted action by EU and Member States.

5.1.2.2 *Development of F2F target 2 indicator*

The second F2F target introduces a use reduction target of 50% for the more hazardous pesticides[109]. The indicator to measure progress will be based on the sales of active substances that belong to Group 3, with average sales in 2015-2017 as the baseline value. As for HRI1 and F2F1, the indicator is an index and only reflects change in Member States, not actual volumes of sales. The trend calculated with this methodology shows a decrease of 12% in 2019 at the overall EU level, from the baseline period 2015-2017, with strong variations between Member States[110].

The evolution on the F2F target indicator will also be strongly influenced by the renewal processes for active substances described earlier. If more active substances currently in other groups are renewed as candidates for substitution or if current candidates for substitution are not approved for use; this will influence the indicator.

If a significant share of the CfS have their approval non-renewed, this may mean that the 50% use reduction target for more hazardous pesticides could be met, without further efforts under the SUD. However, the approval process cannot be predicted, and the achievement of the target will also depend on whether other active substances become CfS and on the volumes of sales per active substance (confidential data), hence it is not possible to estimate. The lack of a strong measure in the CAP to promote and enforce IPM will continue to be an issue.

5.1.2.3 *Development of HRI2 indicator*

Harmonised Risk Indicator 2 (HRI2) is based on the emergency authorisations granted by Member States. HRI 2 is imperfect in that it only records the granting of emergency use, and not the area treated per emergency authorisation, or the quantity of pesticides actually applied. The indicator is

[107] Approved uses for copper primarily involve fungal and bacterial diseases affecting perennial crops (grapes, pomefruit, stone fruit, nuts), vegetable crops (a dozen genera belonging to several different botanical families), perfume, aromatic, and medicinal plants (PAMP); ornamentals; seed-production crops and diseases that develop on tree wounds. Among major field crops, approved uses for copper are limited to potato late blight and a handful of fungal diseases of wheat and rye that are transmitted by seed

[108] A conclusion on whether the 2030 targets have been achieved or not will likely only be possible in 2032 when data for 2030 becomes available.

[109] More hazardous pesticides are plant protection products containing active substances that meet the cut-off criteria as set out in points 3.6.2. to 3.6.5 and 3.8.2 of Annex II to Regulation (EC) No 1107/2009 or are identified as candidates for substitution in accordance with the criteria in point 4 of that Annex.

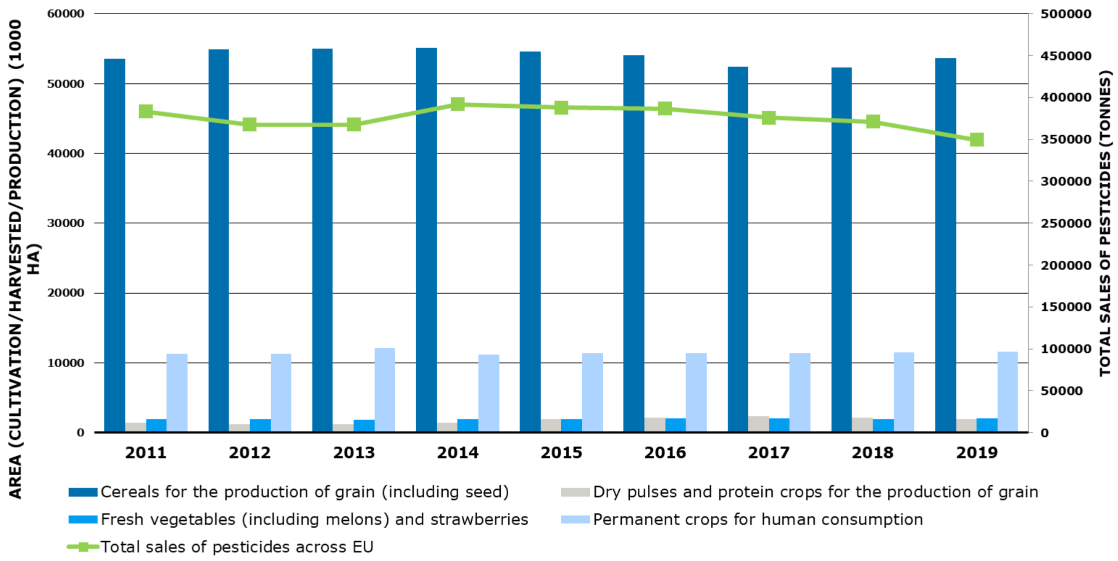
[110] https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/farm-fork-targets-progress_en

measured as an index, with 2011 to 2013 as a baseline. HRI2 for the European Union shows a 55% increase in the period from 2011-2013 baseline period to 2019, but a 5% decrease in 2019 compared to 2018. The drivers behind the increase are likely linked to conditions where pest disease pressure is high, and no PPP is authorised for the specific crop/pest combination (the use).

5.1.2.4 *Development of sales*

The development of sales has been relatively stable over the past years as shown in the graph below.

Figure 2. Total Sales of pesticides across EU 28 against area of cultivation/harvesting/production in hectares



Source: Eurostat (2021). Pesticide sales. Pesticide sales, Dataset: [aei_fm_salpest09] and Crop production in EU standard humidity dataset [apro_cpsh1]

5.1.2.5 *Development of the share of land under organic farming*

The expected development towards 2030 for the share of organic farming is mainly determined by the target for the area under organic production set in the Farm-to-Fork Strategy and specified in the Organic Action Plan[111]. This target aims for 25% of the EU's agricultural land to be farmed under organic practices. Compared to the 2019 share of organically farmed land area of 8.5%[112], this means almost a threefold increase by 2030. In absolute terms, the area of land under organic farming increases from 13.8 million ha in 2019 to 40.6 million ha in 2030. Such an expansion of area for organic production also increases the supply for such products. The market volume of organic produce has been growing substantially in the past and it can be expected to do so in the future. In fact, the growth rate of the retail market has been higher than the growth in organic area for more than a decade[113].

[111] Commission, "Action Plan for the Development of Organic Production."

[112] Eurostat. (2021). Organic farming statistics. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Organic_farming_statistics

[113] FiBL. (2021). The World of Organic Agriculture 2021. Available at: https://www.organic-world.net/yearbook/yearbook-2021/pdf.html

High restrictions on the use of pesticides are one main element of organic farming. The EU Regulation on organic production[114] defines the classes of pesticides allowed under organic practices. Notably, synthetic substances other than a green list in the Annex to that Regulation are not allowed. As such, reduced risk and use of pesticides represents one step on the way towards the transition to organic farming, if for example biological control mechanisms are used.

This limitation, in combination with the required increase in area under organic farming, means that a reduction in the use and risk of pesticides and thus a contribution to reaching the pesticide targets of the F2F strategy can be expected from reaching the target of the Organic Action Plan. Organic farmers will not buy many of the synthetic chemical pesticides that contribute to the calculation of the F2F indicators.

However, quantifying such an effect is challenging due to the uncertainties around the transition. First, some pesticides are approved for use in organic farming. These include copper compounds, which are widely used as bactericides and fungicides, a substance of particular concern to public health or the environment and a candidate for substitution. The use of copper has been limited in the re-approval to 28kg/ha over a seven-year period, equating to 4kg/ha/year[115]. Using a "smoothing mechanism" to take the average of the copper applied in multiple years means that spikes in the indicators are possible in years that have high pressures from pests targeted by copper compounds.

Secondly, the productivity of EU agriculture is likely to change as a result of organic farming, with likely impacts on the needed land area for arable farming. While researchers dispute the fact that a reduction of pesticide use is possible with little impact on the productivity of arable land or not[116], other studies show that yields in organic farming are typically lower, a result of the stricter and broader requirements mentioned just above[117]. In this context, the specific challenges of organically producing certain crops are also factors that need to be considered. While a transition to organic agriculture is easier for some crops, other crops like oilseed rape and vines experience more difficulties[118]. Assuming an unchanged demand in the quantity for food in the EU means that lower yields would have to be compensated by an expanded agricultural area, or – as the previous is difficult within the EU – by increased imports. The use of pesticides would likely rise outside of the EU as a result of this development, as comparable legislative requirements on pesticide use to the EU are rare at the global level currently.

All in all, the activities that will be undertaken to achieve the organic farming target may lead to a reduction of pesticide use overall, but the magnitude and nature of risk reduction is uncertain.

[114] Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control

[115] COMMISSION IMPLEMENTING REGULATION (EU) 2018/1981 of 13 December 2018 renewing the approval of the active substances copper compounds, as candidates for substitution, in accordance with Regulation (EC) No 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market, and amending the Annex to Commission Implementing Regulation (EU) No 540/2011

[116] Martin Lechenet et al., "Reducing Pesticide Use While Preserving Crop Productivity and Profitability on Arable Farms," *Nature Plants* 3, no. 3 (March 1, 2017): 17008, https://doi.org/10.1038/nplants.2017.8.

[117] Elin Röös et al., "Risks and Opportunities of Increasing Yields in Organic Farming. A Review," *Agronomy for Sustainable Development 2018 38:2* 38, no. 2 (February 27, 2018): 1–21, https://doi.org/10.1007/S13593-018-0489-3.

[118] Raphaël Charles et al., "Organic Rapeseed in Switzerland: 20 Years of Practice," *OCL* 27 (2020): 68, https://doi.org/10.1051/OCL/2020055. Charles et al.

IFOAM. 2018. Strategy for the minimisation of copper in organic farming in Europe. Available at: https://www.organicseurope.bio/content/uploads/2020/10/ifoam_eu_copper_minimisation_in_organic_farming_may2018_0.pdf?dd

5.2 Development of the policy options

The tables overleaf present the potential options for revisions to the Directive being considered in the impact assessments. The options are grouped per the identified problems they aim to address, in line with the problem analysis discussed in Chapter 2.

- Uneven implementation of current SUD provisions;
- Monitoring and data availability are limited;
- The SUD not reflecting the ambition of F2F; and
- New technologies are not sufficiently taken up by pesticide users

The options range from least ambitions to most ambitious for each of the identified problems. The European Commission started the process of developing the options on the back of a BTSF[119] workshop with the SUD Working Group held 17-19 November 2020. The workshop was dedicated to discussing the implementation, application and enforcement of the SUD and future perspectives, as an input to the evaluation of the SUD and impact assessment of its potential revision. Subsequent to the workshop, the Commission circulated a list of possible options for revision to Member State Competent Authorities in December 2020, asking Member States to provide initial feedback and additional ideas by 14 January 2021. Member States responded during spring 2021, some with a considerable delay in providing feedback (by October 2021, all Member States had responded). In early 2021, some possible policy options were also shared with members of the Advisory Group on the Food Chain and Animal and Plant Health[120], for feedback and ideas as well as with the Commission ISG for the initiative.

During spring 2021, the Commission also organised a series of technical discussions[121] with SUD Working Group members, aimed at sharing good practices between Member States and discuss possible options for revisions of the SUD. The technical discussion series served to further refine options proposed. In parallel with the consultation work undertaken by the Commission, the evaluation phase of this study to support the back-to-back evaluation and impact assessment was ongoing. Preliminary findings fed into the process of developing possible options for revision, with an early problem analysis and a set of meetings between the study team and Commission staff. Efforts were made to identify possibilities for simplification of the current revisions; however, no clear simplification potentials could be identified, which is in line with the evaluation findings.

On 25 June 2021, the Commission presented and updated overview of draft policy options at the 2nd remote stakeholder event[122]. Proposed options were then considered more or less final, and the support study undertook targeted data collection to feed into the impact assessment work on the proposed options during summer and early autumn 2021. It should be noted that the options provided to the study team for assessment can be considered as “elements of options”, e.g. presented at a disaggregated level which produces a very detailed assessment. Due to high number of “elements” considered, the detailed assessment is provided in Appendix 2 to this report. After an initial assessment provided in the draft final study report on September 15, 2021, the European Commission developed a preferred policy option, combining different elements proposed. The assessment of the preferred option, and other combined options, is discussed in Chapter 8. Due to the very short timeline available for this work, the assessment is a narrative summary of findings, outlining the assumptions and interlinkages. The more detailed assessment, including costs can be

[119] Better Training for Safer Food. See: https://ec.europa.eu/food/horizontal-topics/official-controls-and-enforcement/legislation-official-controls/better-training_en

[120] https://ec.europa.eu/food/horizontal-topics/expert-groups/advisory-groups-action-platforms/advisory-group-fcaph_en

[121] Topics covered were IPM implementation, PAE testing, Drones and spraying, F2F targets, Indicators, Restrictions on pesticide use and Taxation and prescription systems.

[122] https://ec.europa.eu/info/events/sustainable-use-pesticides-second-remote-stakeholder-event-2021-jun-25_en

found in the assessment of elements, Appendix 2. As part of those detailed assessments, interlinkages and dependencies of the different elements are also presented in the appendix.

5.2.1 *Policy options for strengthening current provisions*

Problem	General objective	Baseline	Driver	Specific objective	Least ambitious option	Medium ambitious option	Most ambitious option
Limited operationalisation of IPM principles	Improve practical implementation and operationalisation of IPM principles to reduce the use and risk of pesticides[123] and promote alternatives to pesticides	• Use of IPM is compulsory for all professional users in the EU under the current SUD • Level of implementation is unknown • Most of Member States have not converted the IPM general principles into prescriptive and assessable criteria to be applied by users • Controls and control mechanisms are lacking	• Difficult to "measure" and monitor IPM implementation (especially for purposes of auditing and positive incentives)	• Improve measurability and monitoring of implementation of IPM	• […]	• Establish mandatory common framework for electronic IPM record keeping by professional users[124]; require that those records be transmitted on an annual basis to both MS CAs and the Commission (potential links could be established with e.g.: FSDN[125])	• *Medium ambitious option + the below* • Use mandatory crop-specific IPM standards as a basis for controls and enforcement, using penalties and other remedial measures including under the OCR[126].
			• The operationalisation of the IPM principles is complex and context- and crop specific	• Operationalise IPM principles for different contexts and crops	• Current IPM principles in annex to SUD clarified and reworded (including potential new technologies which can promote the application of IPM principles) • Requirement for MS to establish tailored IPM guidance (region/crop specific) representing crops covering at least 90% of UAA	• […]	
			• Current SUD obligation for MS to introduce incentives for farmers to adopt IPM principles is apparently poorly implemented • Resistance to change in the sector	• Improve implementation of obligation to create incentives / compensation for farmers for using IPM	• Further emphasise the current SUD compulsory requirement for MS to introduce incentives for the use of non-chemical pest control alternatives and methods as well as for any IPM measure that may lead to economic losses for farmers (e.g. crop rotation)	• […]	• […]
			• Lack of advisory services technical services to train and advice farmers on IPM practices • Lack of expertise of advisory services on IPM • Potential or perceived conflicts of interest if advisers recommending the use of particular pesticides and PAE to pesticide users also have an economic interest in selling such products	• Ensure that advisory services can provide robust advice on IPM	• Introduce a legal requirement for more detailed training and holding of a relevant certificate for all advisors	• *Least ambitious option + the below* • Strengthened role and rules for independent advisory service to professional pesticide users (decoupled from economic interest of selling pesticides and PAE), including link to possible prescription system/obligatory advice (see below)	• […]
Poor implementation of the SUD concerning testing of	Improve controls and apply harmonised standards	• No change. To note that enforcement and reporting tools under the Official Controls Regulation (EU)	• Testing of pesticides application equipment is not harmonised	• Harmonise testing of pesticides application equipment across the EU	• Further promote guidelines, harmonised methodology where CEN standards exist and stimulate knowledge sharing among Member States	• *Least ambitious option + the below* • Commission supports drift technology reduction tests, aiming to promote a more harmonised approach at EU level,	• *Medium ambitious option + the below* • Amend OCR to include PAE in its scope

[123] The term "pesticides" is intended to generally signify plant protection products for the purpose of this initiative and biocides are generally excluded from the scope of the work.

[124] The record-keeping could take the form of a decision tree based on IPM pyramid including pest/economic injury thresholds as applicable. 'is a certain tool feasible: yes, no, if not, why not?' Justification and evidence for this and then move to the next decision step in the pyramid

[125] FSDN scheduled to be adopted in Q2 2022. See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12951-Conversion-to-a-Farm-Sustainability-Data-Network-FSDN-_en

[126] Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products,

Problem	General objective	Baseline	Driver	Specific objective	Least ambitious option	Medium ambitious option	Most ambitious option
pesticides application equipment		No 2017/625 do not apply to PAE			• Introduce a requirement for PAE to be registered to facilitate more effective monitoring of PAE and whether it has been inspected and at what intervals. Consider an exemption for low scale use handheld PAE and knapsack sprayers as already provided for in relevant provisions of Article 8 of the SUD	the application of best available technologies (BATs) and the development of standards for PAE	
			• Risk of defective new PAE not being tested before being put into use so that it would be potentially 5 years before the equipment would be tested and such defects identified and resolved	• Improve provisions on inspection intervals	• […]	• Require all new PAE to be tested and certified latest between 6 and 12 months after purchase to avoid that defects and problems might otherwise only be detected years subsequently	• […]
Limited effectiveness of NAPs, delays in production and review	Strengthen effectiveness of the NAPs	• 5 year requirement for review remains	• Level of ambition shown in NAPs differs strongly between MS[127]	• Ensure high level of ambition in all NAPs	• Legislation provides for more specificity as to what is included in NAP • Commission takes stronger line in enforcement of existing requirement and in links to target	• *Least ambitious option + the below* • Template provided on NAP structure and improved Commission guidance on NAP reporting, including reduction of use and risk for health and environment	• […]
			• Reporting intervals are too long to allow for effective monitoring of the situation in MS	• Ensure more frequent reporting from MS	• […]	• Reporting on NAPs has to take place **annually**, including monitoring progress related to F2F targets and outcome of HRI trends[128]	• […]
Pesticide users may have insufficient expertise because they are not subject to training obligations	Improve expertise of pesticide users	• Training for pesticide users as required under Article 5 cannot be assessed in term of effectiveness towards the objective of reducing risk and impact of pesticides	• Training/certification requirements for professional users in the current SUD do not lead to reducing risk and impact of pesticides	• Make training for pesticide users mandatory	• All **operators** of PAE (i.e. pesticide users) to hold a certificate of training **instead** of the current requirement that only the purchaser of the pesticides be trained (i.e. delete current requirement for a training certificate to purchase a pesticide, instead introduce requirement for a training certificate to use pesticides since this is the riskier element rather than merely purchasing a pesticides)	• […]	• […]

[127] See e.g. findings from including:

- More than two thirds of Member States failed to complete the review of their initial NAP within the five-year legal deadline
- Only a small minority of MS identified specific examples of useful targets and indicators based on the review of their initial NAP
- Most Member States have not addressed the weaknesses identified by the Commission in their initial NAPs in their revised NAPs, so that the majority of revised NAPs lack ambition and fail to define high-level, outcome-based targets, so as to reduce the risks associated with, and dependency on pesticides

[128] See also links with options on F2F targets below

5.2.2 *Policy options for strengthening data availability and monitoring*

Problem	General objective	Baseline	Driver	Specific objective	Least ambitious option	Medium ambitious option	Most ambitions option
Knowledge on pesticide use and risk is lacking, and available information not used to the full	Monitor the use as well as the risk of use from pesticides and use the information for policy development at Member State and EU level	• No change to SUD • Problems at EU level with disaggregation of current data and confidentiality limitations. • The statistics on agricultural use of pesticides R1185/2009 annex II, is to be designed by the MS to meet the needs of the MS but MS may not be actively using it for risk management. • Discussions on current agricultural statistics SAIO proposal proceed in parallel (ESTAT)	• Available use data on MS and EU levels is not sufficient to monitor risks from pesticide use • Pesticide users already collect use data which however is not collected	• MS make better use of available use data to allow for better monitoring	• […]	• Oblige MS to collect in electronic manner and analyse the existing pesticide use data currently held by pesticide users under Article 67 of Reg. 1107/2009 and report on this and progress towards reaching the F2F pesticide use and risk targets to the Commission on a yearly basis as well as report at the farm level for a specific (e.g. FSDN) farms sample	• […]
			• Data on pesticide-related poisoning incidents is insufficient for effective monitoring of risk of use of pesticides	• Improve data collection on pesticide-related poisoning incidents	• Mandatory collection by MS of information on acute and chronic poisoning – delete "where available" from current SUD.	• […]	• […]
			• Available information about pesticide-related health and environment risks is insufficient • EU harmonised risk indicators do not allow for effective monitoring of risk	• Improve available information about pesticide-related health and environment risks as well as improve EU harmonised risk indicators	• MS to submit to the Commission and share information on current national health and environment monitoring indicators concerning the use and risk of pesticides as a basis for the possible future development of additional harmonised risk indicators at EU level as requested by European Court of Auditors etc.	• *Least ambitious option + the below* • Based on data collected and progress with relevant research projects such as HBM4EU, IPCHEM, LUCAS, Commission to propose in the longer term specific harmonised indicators[129]	• […]

[129] Obligation in the legal text for the Commission to submit a specific future report and proposal on this issue of new indicators. Impacts of this work introducing potential new HRIs will be assessed in the future.

5.2.3 *Policy options for aligning with pesticide-related targets announced in the F2F Strategy[130] (F2F targets)*

Problem	General objective	Baseline	Driver	Specific objective	Least ambitious option	Medium ambitious option	Most ambitions option
SUD not in line with F2F targets	Align SUD with F2F targets,	• The two F2F targets announced in the F2F Strategy (and referred to in the Biodiversity Strategy) remain as aspirational goals[131]	• Roadmap (incl. monitoring, responsibilities, and governance) towards reaching the F2F targets is unclear	• Define roadmap (incl. monitoring, responsibilities, and governance) towards reaching the F2F targets	• The two F2F targets remain aspirational. Commission monitors progress at EU and MS level annually; in case of undershooting the expected trajectory of achieving the targets by 2030, linked to NAPs each MS shall submit annually a specific action plan to the Commission on measures that will be taken to get back on track towards achieving the targets by 2030	• The two F2F targets are included in a revised SUD as mandatory targets to be achieved at overall EU level. As part of a tailored "effort-sharing approach" among MS, each MS would set their own tailored reduction targets at national level in order to contribute to achievement of the overall EU target and taking account of their existing national situation and level of progress in reducing the use and risk of pesticides. In case of insufficient progress towards reaching the EU level targets by 2030, the Commission would identify additional elements and steps to be taken to get this progress back on track	• The two F2F targets are included in EU legislation as mandatory targets addressed to MSs to be achieved at overall EU and individual MS levels. Each MS would be expected to achieve the two F2F targets based on their starting position during the reference baseline period
	Limit use and risks from pesticides, particularly more hazardous ones[132]	• No change to SUD. Likely that some more hazardous active ingredients would be removed from the market over time. Advances in precision farming would also be expected to be increasingly applied over time and contribute to reducing the use and risk of pesticides	• The outcomes of the current SUD (in terms of **use reduction of more hazardous pesticides;** (see footnote 132) might not be sufficient to meet the F2F targets	• Increase ambition towards reaching F2F target on reducing use of more hazardous pesticides (see footnote 132)	• Prohibit purchase and use of more hazardous pesticides (see footnote 132) by non-professional users (e.g. for them to be used the person would need to be trained)	• *Least ambitious option + the below* • A prescription system for the purchase by professional users of more hazardous pesticides (see footnote 132) • Prohibit use of more hazardous pesticides (see footnote 132) in sensitive areas such as urban green areas	• *Medium ambitious option + the below* • Legal provisions to prohibit the use of **all chemical pesticides** in sensitive areas such as urban green areas[133] as per ambition of Biodiversity Strategy
			• The outcomes of the current SUD (in terms of **use and risk reduction**) might not be sufficient to meet the F2F targets	• Increase ambition towards reaching F2F target on reducing use and risk of pesticides	• [*This is covered by the overall package of policy options*]	• [*This is covered by the overall package of policy options*]	• [*This is covered by the overall package of policy options*]

[130] The two targets are a) reduce the overall use and risk of chemical pesticides by 50% by 2030; and b) reduce the use of more hazardous pesticides by 50% by 2030

[131] Also taking account of the related organic farming target and consequences of complying with that (see recently published Organic Farming Action Plan)

[132] As defined in footnote 13 of the F2F strategy "*These are plant protection products containing active substances that meet the cut-off criteria as set out in points 3.6.2. to 3.6.5 and 3.8.2 of Annex II to Regulation (EC) No 1107/2009 or are identified as candidates for substitution in accordance with the criteria in point 4 of that Annex*".

[133] Specific areas as already defined in Art 12 of the SUD and sensitive areas as explained in recital 16 of the SUD: Use of pesticides can be particularly dangerous in very sensitive areas, such as Natura 2000 sites protected in accordance with Directives 79/409/EEC and 92/43/EEC. In other places such as public parks and gardens, sports and recreation grounds, school grounds and children's playgrounds, and in the close vicinity of healthcare facilities, the risks from exposure to pesticides are high. In these areas, the use of pesticides should be minimised or prohibited. When pesticides are used, appropriate risk management measures should be established and low-risk pesticides as well as biological control measures should be considered in the first place.

5.2.4 *Policy options accounting for new technologies*

Problem	General objective	Baseline	Driver	Specific objective	Least ambitious option	Medium ambitious option	Most ambitions option
Precision farming and development of alternatives not promoted through the SUD	Promote precision farming and the development of alternatives to chemical pesticides through the SUD	• No reference to precision farming nor the development of alternatives is made in the current SUD	• Precision farming not promoted • Development of alternatives is not sufficiently promoted	• Promote the development and application of precision farming • Promote the development of alternative methods/products to reduce the use and risk of pesticides.	• Commission and MS to promote targeted training and advice measures for precision farming to have an efficient uptake from professional pesticide users, • Commission and MS to promote the use of forecasting tools and prediction models and the development of alternative methods that can help to reduce the use and risk of pesticides	• […]	• […]
Drones not accounted for in SUD	Account for drones in the SUD	• No reference to drones is made in the current SUD	• Legal situation on the question if drones fall under aerial spraying is unclear	• Clarify rules for potential aerial spraying by drones	• Clarify that definition of aerial spraying includes spraying by drones	• *Least ambitious option + the below* • Within certain parameters, to be defined in a future legislative Annex, no derogation will be required for aerial spraying by drones[134]	• Any type of **spraying** (including aerial spraying) is allowed without prohibition and without derogation if the spraying instrument is less than 2 metres from the crop being sprayed. Other parameters concerning use and risk would need to be studied and established (retain current prohibition on aerial spraying to allow for spraying by planes and helicopters subject to derogation). • The Commission could adopt a delegating act to account for future technological progress
SUD provisions do not account for emerging technologies and techniques	Revise SUD provisions to account for emerging technologies and techniques	• Current SUD does not account for emerging technologies and techniques	• There are no provisions for testing of PAE or for emerging technologies and techniques	• Create conditions for harmonised testing standards of new PAE technologies	• […]	• Promote (through CEN/ISO) harmonised standards for approval of **additional PAE**, including for precision farming technologies and smart machinery including drones[135]	• […]
			• Potential of precision farming and new technology such as drones, smart machinery and robotics not included in IPM principles	• Include reference to precision farming and new technology such as drones, smart machinery and robotics in IPM principles	• Current IPM principles in annex to SUD clarified and reworded for example to fully reflect the potential of precision farming and new technology such as drones, smart machinery and robotics to reduce the use and risk of pesticides	• […]	• […]

[134] This would include more detailed Commission implementing rules on derogations for aerial spraying using drones to be defined in the future. CEN standards for unmanned aerial vehicles are in development

[135] See also policy option "Require all new PAE to be tested and certified latest between 6 and 12 months after purchase to avoid that defects and problems might otherwise only be detected years subsequently" above

6. What will be the impacts of the different policy options and who will be affected?

6.1 Structure of the impact assessment

Social, economic and environmental impacts are assessed for all policy options. The assessments are grouped into two strands:

1. Assessment of impacts from policy elements that make reaching the two pesticide related F2F targets compulsory for Member States[136]; and
2. Assessment of impacts from the other policy elements, aiming at improving current provisions and implementation of the SUD[137].

The first strand has potentially macroeconomic, environmental and social implications across Europe and, potentially, outside of Europe. However, the pathways are not pre-defined since the mechanism to reach these targets would be determined by Member States, which does not allow for assessing direct costs, such as administrative or compliance cost.

The two pesticide targets focus on two classes of substances. However, these targets overlap, as the reduction of more hazardous substances (F2F pesticide target 2) also falls in the scope of the overall reduction of risk and use of pesticides (F2F pesticide target 1). This connection makes a separate assessment of the two targets difficult. Depending on the alternatives used, progress towards the second target will likely also reflect on the first target. Conversely, a substantial reduction of the overall risk and use under the first target can likely only be achieved through a reduction of the use of more hazardous substances.

Because of their properties that qualify more hazardous substances as such and have led to them being classified as Candidates for Substitution (CfS), the expected impacts described in the previous sections are strongly dependent on the reduction of these substances. In particular, environmental and human health benefits are linked to a reduction of those pesticides that include bioaccumulating, carcinogenic or reprotoxic substances.

Therefore, the reduction of pesticide risk is substantially influenced by the use of more hazardous substances. This is reflected in the calculation method of HRI 1 as well as the F2F indicators, where CfS have high factors for their sales quantities and therefore reduce these indicators. As outlined repeatedly, the reduction in use of more hazardous substances also relies to large extents on their authorisation and (non) renewal.

The uncertainties of the renewal decisions and the substitution with alternatives are two key factors why the quantified separation of the two targets is not feasible.

The second strand aims at reducing the use and risk from pesticides. However, it is challenging to differentiate the contributions from individual provisions to the overall objectives of use and risk reduction and the extent to which they together contribute to the objectives. This is due to a few reasons which are listed below:

- Many of the provisions together (e.g. training and promotion of IPM) aim at accomplishing a behavioural change among pesticide users which is impossible to measure or predict with any certainty;

[136] See chapter 7

[137] See Appendix 2

- Other provisions aim at supporting policy monitoring and enforcement which provide a framework for behavioural changes, but have no direct effect on pesticide use; and
- The elements reinforce each other and are to some extent interdependent (one will not function without the other).

Hence, for most of the policy elements[138], it is very challenging to assess their social, macroeconomic and environmental impacts, other than in qualitative terms. However, the policy elements have potentially direct economic costs (such as administrative costs) which have been assessed when possible.

Based on the reflections above, the following assessments of impacts are presented:

- An assessment of social, macroeconomic and environmental impacts in the EU as well as outside of Europe of the situation in which the two pesticide related F2F targets are made legally binding, and thus reached, by 2030. This is summarised in Chapter 7, with the underlying in-depth assessments in Appendix 1.
- A qualitative assessment of the likely social, economic and environmental impacts and a quantitative assessment of direct economic costs of the other policy elements proposed by the European Commission. This is presented in Appendix 2.
- A summary analysis and assessment of options for revision of SUD, combining the policy elements proposed, including the preferred option identified by the European Commission. This is presented in Chapter 8.

6.2 Approach to the comparison of proposed options

The comparison of proposed revisions is structured around the groups of policy elements being assessed, i.e. the following:

- Policy options strengthening current SUD provisions;
- Policy options addressing data availability and monitoring;
- Policy options addressing alignment with pesticide-related targets announced in the F2F Strategy; and
- Policy options addressing new technologies

Under each of the groups there are several specific objectives grouped together. Each specific objective has a number of proposed policy options to achieve them, respectively. Thus, the main level of comparison of policy option is at the level of the specific objective. The comparison is included in the Appendix 2, where the detailed assessment is presented.

The options are compared using the following criteria:

- **Impacts**
- **Effectiveness** – An assessment of the extent to which the different options are expected to achieve the respective specific objectives.
- **Coherence** – The extent to which the different options interact with other relevant areas and instruments of EU and international policy
- **Efficiency** – In the detailed assessment, the assessment of costs has been broken down per stakeholder group and assesses direct compliance costs and enforcements costs, where possible in quantitative terms and else qualitatively. Benefits in almost all cases entail improved welfare through health, safety and environment benefits which concern society as a whole. The assessment of efficiency thus is done in terms of cost effectiveness, i.e. an assessment of the

[138] There are a few exceptions to this, like e.g. the policy options to also test and certify new PAE which could lead to direct avoided environmental impacts due to better condition of the equipment

ratio between the costs (combined across all stakeholder groups) and the expected effectiveness of reaching the specific objectives.

- **Proportionality** – Assessing the proportionality of different options. This entails if the efforts required to implement the different measures are proportionate to the benefits that can be expected from achieving the specific objective.
- **Subsidiarity** – Assessing the compliance with the subsidiarity principle of the different options.

Each criterion is ranked using the following scale:

- /: no impact
- Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
- Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)
- (): brackets if costs, benefits etc. are only potentially
- If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +

It should also be noted that the criteria are not equally relevant for each of the policy options, so that not all of them have been assessed to the same extent under each sub-option. All criteria have, however, been considered in the assessment.

7. Assessment of social, economic and environmental impacts of the Farm to Fork pesticide targets

7.1 Introduction

In this section the F2F pesticide targets are assessed for their potential impacts on human health/social, macro and microeconomics and the environment should the targets become legally binding. In this sense, the impact assessment (IA) looks at what the impact would likely be of achieving the targets by 2030.

It is an intrinsically difficult exercise, since there are numerous inter-relations and interdependencies between the drivers of change and their consequences (impacts), and with influencing factors outside the scope of this study. To address this, the IA takes a systemic approach to highlight rather than disregard the complexities involved. The impact sections discuss a set of key indicators for environment, macroeconomic, microeconomic and social (health) impacts respectively. A full account of the IA is presented in Appendix 1.

7.2 Approach

The baseline scenario is dynamic assuming that the SUD and related policies (except the pesticide-related targets in the F2F Strategy) continue the current trajectory through to 2030, and that other influences, such as climate change, continue to affect the environment, economics and wellbeing. Then, the assessment of social, economic and environmental impacts (positive and negative) of the F2F pesticide targets relied on the mapping and identification of material impacts and associated indicators of impact from achieving those targets. The environmental, economic and social indicators selected were representative of the main categories of impacts (both intended and unintended, and short and long term) across the key stakeholders. An in-depth literature review was conducted with a view to:

- Identify indicators and metrics to qualitatively or quantitatively predict the relationship between reduced (hazardous) pesticide use and potential impacts; and
- Identify the most recent and comprehensive evidence base to inform the evolution of each indicator in the 2020 to 2030 baseline and in the scenario in which the pesticide-related targets announced in the F2F strategy are achieved.

The literature review was supplemented with information gathered through the focus groups (see Appendix 1) and the case studies. Generally, the relationship between the change in pesticide use and environmental, economic and social impacts is not linear, thus the team focused on the broad understanding of the problem and the main drivers of change in order to make informed projections of the anticipated change relative to the baseline for each indicator when directly relevant or quantitative data were unavailable. Regulatory reports and peer-reviewed literature were prioritised.

It is important to note that irrespective of proposed policy changes to the SUD, the agri-food sector will undergo a transition driven, amongst others, by increasing global demand for food and fuel, technological and dietary shifts, productivity constraints, climate change and the new policy landscape. For example, pressures on the environment, consumer health, and food supply and demand will arise from a mix of strategies and policies, including but not limited to the F2F Strategy, European Biodiversity Strategy, CAP reform and the Green Deal. These wider policy, environmental, demographic, technological and economic factors will influence EU agri-food production, the evolution of plant protection product and agri-food value chains and non-EU trade on agricultural goods (see Drivers, section 5.1.1).

The complexity of the interconnections and non-linear relationships between the various drivers of change limits the availability of reliable predictions of change to 2030 in the baseline. These limitations are not bridged in the literature and significant outstanding research and innovation gaps exist in relation to (i) fully integrated and viable (technically and economically) solutions that reduce the need for pesticide inputs; and (ii) robust and integrated characterisation of impacts on the environment and across the wider range of stakeholders of the mix of policies that will shape the baseline. Furthermore, the synergistic nature of these policies makes it difficult to estimate the additionality of SUD in relation to its contribution to reaching the pesticide-related targets announced in the F2F Strategy, and its associated environmental, economic and human health impacts. These limitations and the resulting gaps in evidence base have shaped the approach of the assessment presented in this document.

It was beyond the scope of this IA to model or generate new evidence, therefore, gaps were filled using professional judgement with data gaps, limitations and assumptions noted in the report.

7.3 Overview of Drivers

Key drivers influencing the evolution of the baseline over the period 2020 to 2030 are identified below and further elaborated in the analysis (Appendix 1). The influence of key drivers on particular actors or value chains are highlighted, however this IA does not attempt to quantify the particular influence of individual drivers across those stakeholder groups, not least given the complexity of the interconnections and the non-linear feedback loops across them. A summary of drivers is presented in Table 7.1.

From the environmental perspective, agricultural policy has been influential in shaping European landscapes and the nature they contain. The pressures and threats to ecosystems most frequently reported by Member States are associated with agriculture[139]. Europe is experiencing a decline in biodiversity primarily due to the loss, fragmentation and degradation of natural and semi-natural ecosystems and agricultural intensification is one of the main causes.

One of the main mechanisms to address environmental pressures from agriculture has been the mainstreaming of environment and climate objectives into the CAP, which has had some success for nutrient emissions, but is tempered by the continuing decline in biodiversity. The European F2F and Biodiversity strategies follow from the EU Green Deal, although both the European Parliament and the Council of the EU voted against the explicit inclusion of the strategies' targets in the CAP for the 2020-2027 period, however the CAP still represents the greatest opportunity of drivers for environmental change in the agriculture sector. The influence of the CAP policy is discussed in concert with the pesticide-related targets of the F2F Strategy.

[139] EEA (2015). Briefing paper: Agriculture. Published 18 Feb 2015. Available at: https://www.eea.europa.eu/soer/2015/europe/agriculture

Table 7.1. Overview of key drivers influencing the evolution of the baseline

	Drivers	Influence
Environmental variability and natural resources	• Crop type (permanent or annual; self-fertilising), crop cover, intercropping, mulching, cultivar mixtures, fallow land • Soil-related drivers, such as soil type • Water-related drivers, such as protection of drinking water resources • Biodiversity-related drivers, such as buffer zones and field margins • Pollinator-related drivers, such as disease • Land use change, habitat fragmentation and loss of habitat connectivity • Invasive alien species, especially in island ecosystems (habitat fragments) • Biological pest control, including distribution of natural enemies • Fluctuations in pest pressure, crop and animal diseases • Timing and frequency of applications • Pesticides and other chemical mixtures leading to synergistic or additive toxicity • Existing levels of contamination, including residues • Weather and extreme events, such as drought, rainfall and floods, extreme temperature and wildfires • Resource scarcity and competition for access	Greater biodiversity will increase resilience to shock events, influencing yields, food loss and prices.
Demographic and social developments	• Size of world population and ageing EU population • Generational shift of farmers and consumers • Migration • Urbanisation • Dietary shifts • Public opinion and concerns about health and environmental impacts of pesticide use	Growing population will increase global competition for food; dietary and cultural influence on food production and trade. Growing concerns in society about the impact of food production on the environment[140] acts as drivers for change.
Economic influence	• Changes in crop distribution/crop type • Changes in pesticide price and availability • Competition for land/land use changes • Economic growth and globalisation (e.g. trade, rise of emerging economies, developments in agricultural markets) • Structure of the agro-food sector (power distribution competition, price transmission, etc) • Evolution of the farming sector to face environmental challenges, policy changes and consumption models • Agricultural subsidies • Availability of farm advisory and training services • Addressing investment needs for securing compliance with EU objectives and matching these with available funding sources	Changes in land use/crop reallocation, farm size, productive farm orientation and business structure; new trade agreements, development and uptake of new technologies across the entire agri-food value chain

[140] See for example the European Citizens initiative "Save Bees and Farmers" https://www.savebeesandfarmers.eu/eng

	Drivers	Influence
Science and Technological influence	• Change in pesticide application methods • Biotechnology (new breeding technologies; synthetic biology; alternative protein sources; food design; bioenocomy) • Digitalisation (precision agriculture; automation & robots; connectivity; virtual services and servitisation) • Technological development • Efficiency improvements • Availability of low-cost PPP alternatives • Making effective use of the existing knowledge base to innovate further towards land sustainability in the agricultural sector • Less persistent (hazardous) pesticides • New scientific data and understanding of the safety of new or existing active substances	Technological progress (together with the economic viability of new technologies) will improve resource efficiency and productivity and will drive competition, structure, employment and profitability of farming sector and PPP value chain
Policy influence	• EU climate targets, carbon farming in the EU, international climate agreements • Environmental policies - EU Biodiversity strategy; Convention on Biological Diversity (COP15) – nature positive targets - EU Pollinator Initiative - EU Soil Thematic Strategy - Water policies, e.g. WFD, Groundwater Directive • Just transition • Farm incomes - Value distribution in food chain - Food security, nutrition and public health - Food affordability and supply sector competitiveness • Organic action plan; increased area of organic farming • Food waste • Circular bio-economy and agricultural loss reduction • 'Greening' of the CAP • Legislative framework for sustainable food systems • Dietary shifts (i.e. a reduction in calorie content and animal products) Better policy implementation; ensuring governance structures that allow effective coordination	Climate mitigation and adaptation, avoidance of biodiversity loss and net gain targets met. Reduced environmental impact from food production along with measures to increase circularity, minimise waste and reduce the demand for the most unsustainable food products. Degree to which these aspects will be incorporated into trade agreements to reduce leakage remains unclear.

7.4 Overview of Impacts

The section below presents an overview of the main environmental, economic and human health impacts of reaching the two F2F pesticide related targets. A detailed assessment is presented as Appendix 1.

It can be noted that the recent European Citizens' Initiative (ECI) "Save Bees and Farmers"[141], which closed on September 30 2021, call for even stronger action on pesticide reduction than the F2F Strategy. The ECI generated 1.2 million signatures[142], calling on the European Commission and European Parliament to act for the use of synthetic (chemical) pesticides to be gradually reduced by 80 percent in EU agriculture by 2030 and completely phased out by 2035. This IA study has not assessed the impact (or feasibility) of these targets, but it would likely mean that environmental, economic and social/health impacts analysed in the following sections would increase in magnitude, and some also in distribution and direction, leading to new or more significant and far-reaching trade-offs, farming practices and rural landscape changes.

7.4.1 Environmental Impacts

The approach to the IA takes a holistic environmental perspective of sustainable pesticide use for food or biofuel production. The indicators align to an ecosystem services approach advocated by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) as one factor for increasing the effectiveness, efficiency and equity of the CAP[143], it also underpins the EU Biodiversity Strategy, and is used by the EFSA in its Specific Protection Goals in PPP authorisation[144]. The integration of an ecosystem services approach to pesticide risk assessment was also recently promoted in a CEFIC and SETAC workshop[145,146,147]. Importantly, an ecosystem services approach can illustrate trade-offs between services in-field (cropped area) and off-field (surrounding environment), and incorporate socio-economic information, to inform policy decisions on active substances (and alternative forms of pest control) at regional and national scales. These methods and case studies already exist to promote the sustainable use of pesticides.

The primary in-field ecosystem service is generally optimised for food, feed, fibre, energy and other products for human consumption and processing with benefits for farm revenue. In and around the crop, semi-natural features (e.g. field margins, hedges, grass strips, lines of trees, ponds, terraces, patches of uncultivated land) are an important part of agroecosystems, as they are managed within the same context and affected by agricultural activities, and from an ecological perspective they are nesting and breeding sites, food sources, migratory corridors to fauna, supporting ecosystem services such as pollination, pest control and other regulating and cultural ecosystems services. Moreover, agrobiodiversity and in particular genetic resources for food and agriculture (e.g. wild

[141] https://www.savebeesandfarmers.eu/eng/

[142] At the time of drafting this report, the signatures have not been verified by Member States. Therefore, this is a preliminary number.

[143] IPBES (2021). IPBES-IPCC Co-Sponsored Workshop Report on Biodiversity and Climate Change, Online Event. Available at: https://ipbes.net/events/launch-ipbes-ipcc-co-sponsored-workshop-report-biodiversity-and-climate-change

[144] EFSA Scientific Committee. (2016). Guidance to develop specific protection goals options for environmental risk assessment at EFSA, in relation to biodiversity and ecosystem services. EFSA Journal. 2016 Jun;14(6):e04499.

[145] https://cefic-lri.org/projects/eco-45-chemicals-assessment-of-risks-to-ecosystem-services-cares-ii/

[146] Maltby L, Brown AR, Faber JH, Galic N, Van den Brink PJ, Warwick O, Marshall S (2021) Assessing chemical risk within an ecosystem services framework: Implementation and added value Science of the Total Environment

[147] Van den Brink PJ, Alix A; Thorbek P; Baveco H; Agatz A; Faber JH; Brown AR; Marshall S; Maltby L (2021) The use of ecological models to assess the effects of a plant protection product on ecosystem services provided by an orchard. Science of the Total Environment 798: 149329

crop relatives) represent an insurance for the future, guaranteeing the capacity to respond to crises contributing to food security[148].

In this IA, the selection of environmental indicators has been informed by the 2020 EU Ecosystems Assessment report (see Mapping and Assessment of Ecosystems and their Services - MAES[148]), which is based on European wide, harmonised datasets focussed on five types of ecosystem service categories (i) biodiversity and landscapes; (ii) maintenance of soil quality; (iii) water quality regulation and aquatic biodiversity; (iv) crop pollination; and (v) biological pest control.

Most of this IA focusses on intensively and conventionally managed agricultural landscapes, primarily annual crops. This presents an imbalance in the IA as there are many types of crops cultivated in different ways, which may be less impactful on the environment, for example, permanent crops can provide many ecosystem services benefits, such as recreational spaces and strong regional traditions and identity (e.g. cider making, citrus and olive groves)[149].

Interpreting the 50% reduction in hazardous pesticides target in the F2F Strategy for the environment

It is not yet clear in policy how the F2F targets of the 50% reduction in use and risk of chemical pesticides and the 50% reduction in the most hazardous pesticides would be implemented, however, existing measures are in place. Active substances undergo rigorous environmental risk assessment and regular systematic review. When a pesticide is reviewed national authorities need to carry out a comparative assessment to establish whether more favourable alternatives to using the pesticide exist, including non-chemical methods, these are known as candidates for substitution (CfS) under Regulation 1107/2009. The aim is to encourage more sustainable crop protection.

The current CfS list comprises a mix of active substances, mainly identified for environmental hazard (e.g. persistence and bioaccumulation properties) or human health effects. It is unclear how the 50% reduction in the most hazardous PPP target in the F2F Strategy would be achieved. Using currently available information on CfS downloaded from the European Commission Pesticides Database[150], one-third of active ingredients were not approved for use between 2017 and 2021 (35 of 103 active ingredients). There are 68 active ingredients currently approved for use on the CfS list with 50 of these Candidates identified as being of concern for "two PBT criteria". Member States have identified these as being of potential environmental concern for persistence, bioaccumulation or (eco)toxicity (PBT). It is noted that four substances are copper based and sold as organic pesticides (fungicides). It may be assumed in the baseline scenario that some of these active substances will not be re-approved in the years up to 2030.

There are 20 CfS identified on human health grounds, which is unlikely to make a substantial difference to water or soil quality or biodiversity, although may influence groundwater quality and drinking water resources. The IA scenario questions the additionality of a 50% reduction in

[148] Maes, J.,et.al., Fernandez Ugalde, O., Santos-Martín, F., (2018). Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN, Publications Office of the European Union, Ispra, 2020, ISBN 978-92-76-17833- 0, doi:10.2760/757183, JRC120383.

[149] Deacon, S., Norman, S., Nicolette, J., Reub, G., Greene, G., Osborn, R. and Andrews, P., 2015. Integrating ecosystem services into risk management decisions: Case study with Spanish citrus and the insecticide chlorpyrifos. Science of the Total Environment, 505, pp.732-739

Van den Brink PJ, Alix A; Thorbek P; Baveco H; Agatz A; Faber JH; Brown AR; Marshall S; Maltby L (2021) The use of ecological models to assess the effects of a plant protection product on ecosystem services provided by an orchard. Science of the Total Environment 798: 149329

[150] Candidates for Substitution list downloaded on 19 August 2021 - https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/active-substances/?event=search.as

hazardous pesticides target. It is assumed that emergency authorisations at Member State level will continue under both baseline and IA scenarios.

7.4.1.1 *Biodiversity and landscapes*

Biodiversity and nature sustain life on Earth, delivering numerous essential ecosystem services. They are a vital element of our cultural heritage and treasured for their recreational and aesthetic values. As a result, biodiversity loss has fundamental consequences for our society, economy and for human health and well-being. Biodiversity underpins our landscapes and the resilience of traditionally cultivated agricultural land often depends on the diversity of species and habitats adjacent to cropped areas for recolonisation and recovery. The European Commission states that forests and agroecosystems dominate the 4.4 million km^2 of EU land area (EU27 and UK), and the European Ecosystem Assessment (EU, 2021) reported that agroecosystems cover almost half of the EU land area (36.4% cropland and 11.4% grassland). Such dominance of European land usage present substantial opportunities for ecosystem restoration and climate mitigation through increased sustainable agricultural and forestry practices[143].

The main policy driver is the EU Biodiversity Strategy for 2030 which addresses the main causes of biodiversity loss with the renewed objectives of halting this loss and restoring damaged ecosystems. Intensive farming prioritises food (and biofuel) production to secure livelihoods and to feed (or generate energy) for the population. However, intensification of agriculture has had a range of negative consequences for the health and quality of natural ecosystems. Partly, this arises from the use of inputs such as pesticides and chemical fertilisers, and partly it is a function of the prevalence of 'monocultural landscapes' in which there is little opportunity for nature. In turn, the loss of biodiversity leads to a need to intensify agriculture further[151]. So far, the CAP scheme has incentivised larger farms and the intensification of agriculture[121].There may be opportunities in the CAP reform to incentivise ecological restoration and biodiversity enhancement at farms of all sizes.

Some key references for the baseline scenario include recent reports from the European Environment Agency and the European Ecosystems Assessment. The EEA State of the Environment (2020) generally reports a "mixed picture" for the outlook on biodiversity, and a deterioration in common species to 2030. It states that despite ambitious targets, Europe continues to lose biodiversity at an alarming rate and many agreed policy targets will not be achieved. Long-term monitoring shows a continuing downward trend in populations of common birds and butterflies, with the most pronounced declines in farmland birds (32%) and grassland butterflies (39%). Europe's biodiversity and ecosystems face cumulative pressures, such as land use change, with the EU Ecosystems Assessment showing similar declining trends in biodiversity. The EEA admits that biodiversity targets to 2030 will not be met without more effective implementation and funding of existing measures in all European environmental policies, as well as greater policy coherence with respect to biodiversity in agriculture, such as incentivisation through CAP payments for ecological restoration and biodiversity enhancement.

The baseline scenario was informed by studies that showed measures introduced in the CAP through agri-environmental schemes to reduce the environmental impact of agriculture have brought some positive outcomes, including effective buffering of sprayed areas to reduce impacts of pesticides on biodiversity[152], although, the CAP's other measures have been less successful. For example, greening measures accounted for 30 % of the direct payments budget, introduced in the 2013 CAP

[151] Benton T, Bieg C, Harwatt H, Wellesley L, Pudasaini R. (2021). Food System Impacts on Biodiversity Loss Three Levers for Food System Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House.

[152] Aguiar, T.R., Bortolozo, F.R., Hansel, F.A., Rasera, K. and Ferreira, M.T., (2015). Riparian buffer zones as pesticide filters of no-till crops. Environmental Science and Pollution Research, 22(14), pp.10618-10626.

for biodiversity, soil quality and carbon sequestration, but have been shown to be ineffective[153], leading to positive changes in farming practices on only 5% of EU farmland. Similar measures will not be sufficient to halt biodiversity loss to 2030 and instead the SUD and CAP should work together for full alignment with United Nations Sustainable Development Goals, including an increase in expenditure on sustainable development priorities and at the same time the phasing out of spending that is not in line with these priorities. The Commission's Green Deal, as well as the strategies for sustainable food and biodiversity protection, can provide a common direction of travel at EU level – but only if the EU has clearly defined 2030 targets as to where the agriculture, forestry and wider food sectors must make an active and measurable contribution. This includes the sustainable use of pesticides.

Agriculture requires changing ecosystems from their natural state into a managed state and the more food the system must produce, the less suitable it becomes as habitat for wildlife[151]. Broadly speaking, to produce a given amount of food (or biofuel crop), a large area of land can be used and farmed in a more wildlife-friendly way (but with smaller yields per area), or a smaller area of land can be farmed more intensively (with larger yields per area). This is the essence of the 'land-sharing' vs 'land-sparing' debate, which seeks to understand how best to integrate the needs of wildlife alongside the use of land for agriculture[151]. The most appropriate strategy depends on three factors: (1) how much more beneficial natural ecosystems are for biodiversity relative to nature-friendly farming systems; (2) the degree to which spillover effects (such as pesticide application) can be minimised; and (3) governance of the spared land (including its amount, type, location and protection). Many studies have now shown that in principle land-sparing can be more effective for biodiversity conservation[154] and is potentially better for other aspects of sustainability.

The European State of the Environment (2020) reported structural parameters characterising farmland (crop diversity, high nature value farmland) have remained stable to 2020 at around the 2010 level, as has the share of agroecosystems under protection by EU and national legislation. Although the targets in the EU Biodiversity Strategy are heading in a positive direction for biodiversity, the targets are modest and without implementation of the EU Biodiversity Strategy through the CAP or other policy incentives relating to land management (e.g., land sparing or sharing), it is likely that little will change to 2030, i.e. declining biodiversity will continue.

In terms of the IA scenario, the additionality of the pesticide targets in the F2F Strategy are unlikely to have a substantial influence on biodiversity and landscapes. The Ecosystems Assessment[155] reports habitat change, including loss and fragmentation, have had the greatest overall impact on ecosystem services and they appear to be on the increase in more than 60% of ecosystems assessed.

7.4.1.2 *Maintenance of soil quality*

Soil is a vital asset to farmers as healthy soils contribute to healthier crops. Soil is composed of mineral particles, organic matter, water, air and living organisms, and is in fact an extremely complex, variable and living medium hosting 25% of the world biodiversity, twice the amount of carbon that is found in the atmosphere and three times the amount found in vegetation, and some

[153] European Court of Auditors (2017). Special Report No 21; Greening: a more complex income support scheme, not yet environmentally effective

[154] Balmford, A., Amano, T., Bartlett, H., Chadwick, D., Collins, A., Edwards, D., Field, R., Garnsworthy, P., Green, R., Smith, P., Waters, H., Whitmore, A., Broom, D. M., Chara, J., Finch, T., Garnett, E., Gathorne-Hardy, A., Hernandez-Medrano, J., Herrero, M., Hua, F., Latawiec, A., Misselbrook, T., Phalan, B., Simmons, B. I., Takahashi, T., Vause, J., Ermgassen, E. and Eisner, R. (2018), 'The environmental costs and benefits of high-yield farming', Nature Sustainability 1(9): pp. 477–85.

[155] Maes, J., et.al. (2020). Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN, Publications Office of the European Union, Ispra , ISBN 978-92-76-17833- 0, doi:10.2760/757183, JRC120383.

95% of our food is directly or indirectly produced from our soils. It is an essential ecosystem serving as a platform for human activities and landscapes, but its formation is an extremely slow process and may be considered as a non-renewable resource. This is also reflected in the EU Soil Strategy for 2030[156].

Some drivers that are specific to soil quality include crop cover, mulching, intercropping, cultivar mixtures, fallow land, slope and erosion potential; soil compaction; soil type (and depth); soil organic carbon content; water holding capacity; habitat loss and decline in biodiversity, including soil sealing, particularly through urban expansion into agricultural land and wider countryside; and soil policies, such as the EU Soil Thematic Strategy.

Many definitions of soil quality exist and generally incorporate biological, physical and chemical components[157,158] who recommended more than 70 indicators of soil quality. Common indicators include organic matter, pH, available phosphorus and water storage, with increasing calls for more biological indicators, some of which would tie in well with ecotoxicological testing in PPP regulatory risk assessment and could lead to more relevant functional testing and monitoring of soil ecosystems. Soil organic carbon is especially important with the focus on the climate crisis and the opportunities that soil ecosystems bring for carbon sequestration in climate mitigation. Also, measures that relate to the maintenance of soil structure and water cycling are important when, for example, when farmers shift from traditional pesticide application regimes to wider uptake of integrated weed management (IWM) and mechanical weed management. Use of tillage implements like harrows and weeders can have detrimental effects, such as releasing carbon from the soil, lowering soil organic matter, soil compaction and other impacts, leading to increased soil erosion, fuel consumption/climate warming, leaching of plant nutrients and nutrient/pesticide runoff into waterbodies. There can be conflict between short-term pressures to maximise monetary returns through intensive soil cultivation and high yields in agriculture, and long-term sustainability of the soil. The ability of soil to produce ecosystem services offer benefits to society as a whole.

For the baseline scenario, the outlook in the European State of the Environment report is one of deterioration in land and soil quality to 2030. The 2021 European Ecosystem Assessment reported that one of the main pressures on agricultural soils - use of pesticides - has remained stable over the last 10 years, so has the structural condition of agroecosystems (measured by indicators including landscape mosaic, crop diversity). However, the European Ecosystem Assessment and European State of the Environment reports concur that agricultural soils are being lost to urban expansion (soil sealing) and degraded by intensive agriculture practices resulting in soil compaction, contamination, loss of organic matter and biodiversity, with increased soil erosion.

Growing pressures on the available agricultural land and soil resources are exacerbated by the impacts of climate change, although substantial opportunities for climate mitigation are available through carbon sequestration and storage in agricultural soils.

It is expected that restrictions in use would continue in the baseline scenario to 2030 through the Candidates for Substitution approach under Regulation (EC) No 1107/2009 and be influenced by effects on soil organisms, however, priority substance pesticides or newly restricted pesticides may persist in soil systems to 2030 (and possibly beyond), even in organic soil ecosystems. There are

[156] EU Commission. EU Soil Strategy for 2030. (2021). Reaping the benefits of healthy soils for people, food, nature and climate. COM(2021) 699 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0699

[157] Bünemann EK, Bongiorno G, Bai Z, Creamer RE, De Deyn G, de Goede R, Fleskens L, Geissen V, Kuyper TW, Mäder P, Pulleman M. (2018). Soil quality–A critical review. Soil Biology and Biochemistry. 2018 May 1;120:105-25.

[158] Thomsen M, Faber JH, Sorensen PB. (2012). Soil ecosystem health and services–Evaluation of ecological indicators susceptible to chemical stressors. Ecological Indicators. 2012 May 1;16:67-75.

uncertainties around mixture toxicity and the potential for combined effects of pesticides and other chemicals on soil systems.

In the IA scenario, the additionality of the reduction in 50% of the most hazardous pesticides target in the F2F Strategy - where these have the potential to affect non-target terrestrial plants, soil fauna and soil microbial process - is likely to be beneficial for soil biodiversity. However, it is unlikely that the pesticide targets alone will improve soil quality when a range of biological and physico-chemical indicators are considered.

7.4.1.3 *Water quality*

Using pesticides protects crops and maintains yields, but pesticides applied to crops, under certain conditions such as heavy rainfall after application, can enter surface and ground water where they may adversely affect plants and animals and may contribute to biodiversity loss in aquatic ecosystems[159]. It is reported that diffuse pollution poses the second main pressure (38%) on the aquatic environment with agriculture being the main contributor[160]. Whereas for groundwater, agriculture is the main cause for failure to achieve good chemical status due to diffuse pollution from pesticides (and nitrates).

In the baseline scenario, the European Environment Agency reported that Europe is not on track to meet policy objectives on water quality. It predicted a 'red light' warning in its outlook to 2030 based on continuing progress to restrict pesticide use. Regulatory monitoring for European surface water between 2007 and 2017 records exceedances of quality standards of 5–15% by herbicides, 3–8% by insecticides, and negligible exceedances for fungicides. Whereas for groundwater, the exceedances of quality standards were about 7% for herbicides and below 1% for insecticides, whilst also being negligible for fungicides[161]. An exceedance of a surface water quality standard may indicate the potential for an adverse effect on aquatic ecology and may be viewed as a trigger for further assessment to determine whether a risk is realised.

Studies have shown that insecticides may be responsible for more than half, and herbicides for more than one-quarter, of acute risks to aquatic life in the EU[162]. Also, that only a few pesticides may account for most of the risk to aquatic life[163,164,165]. However, reliance on the reporting of priority substances under the Water Framework Directive (WFD) may be under-representative of the most hazardous pesticides currently in use[166], as it includes pesticides that are already restricted in Europe. Currently, the EC reviews the lists of pollutants under the WFD, the Environmental Quality Standards Directive (EQSD) and the Groundwater Directive (GWD) which may have a positive impact depending on the outcome. Monitoring frequency (typically up to 12 times per year) misses

[159] European Court of Auditors. (2020). Biodiversity on farmland: CAP contribution has not halted the decline – special report.

[160] EEA (2020). State of the Environment Report

[161] EEA. (2020).ETC/ICM Report 1/2020: Pesticides in European Rivers, Lakes and Groundwaters - Data Assessment. https://www.eionet.europa.eu/etcs/etc-icm/products/etc-icm-report-1-2020-pesticides-in-european-rivers-lakes-and-groundwaters-data-assessment.

[162] Wolfram J, Stehle S, Bub S, Petschick LL, Schulz R. (2021). Water quality and ecological risks in European surface waters–Monitoring improves while water quality decreases. Environment International. 2021 Jul 1;152:106479.

[163] Underwood, E and Mole, N (2016). Effective policy options for reducing environmental risks from pesticides in the UK. Institute of European Environmental Policy.

[164] Van Klink R, Bowler DE, Gongalsky KB, Swengel AB, Gentile A, Chase JM. (2020). Meta-analysis reveals declines in terrestrial but increases in freshwater insect abundances. Science. 368(6489):417-20.

[165] van Eerdt MM, Spruijt J, van der Wal E, van Zeijts H, Tiktak A. (2014). Costs and effectiveness of on-farm measures to reduce aquatic risks from pesticides in the Netherlands. Pest management science. 70(12):1840-9.

[166] Rasmussen JJ, Wiberg-Larsen P, Baattrup-Pedersen A, Bruus M, Strandberg B, Soerensen PB, Strandberg MT. (2018).Identifying potential gaps in pesticide risk assessment: Terrestrial life stages of freshwater insects. Journal of applied ecology. 55(3):1510-5.

the short time in the growing season when a pesticide may enter surface waters after use and averaging concentrations over a year means threshold standards for chronic exposure are not exceeded. Also, small waterbodies may not be routinely monitored.

In the baseline scenario it is expected that restrictions in use would continue to 2030 through the Candidates for Substitution approach under Regulation 1107/2009 and be influenced by WFD policies and National Action Plans under SUD. To understand and manage risks to water quality, the ecological and landscape contexts must be accounted for in risk assessment, such as, the sensitivity and functions of organisms, habitat type and climate, and site-specific aspects such as the connectivity to nearby populations (for re-colonisation) and presence of additional stressors.

Restrictions and changes in practice prior to 2020 have been enacted on specific active substances and these controls have been effective, however, priority substance pesticides or newly restricted pesticides may persist in aquatic systems to 2030 (and possibly beyond). This has implications for the IA scenario as it means that water quality is unlikely to instantly improve when active substances are withdrawn, for example, the European ban on atrazine has led to substantial declines in concentrations found in coastal waters[167], however, the herbicide was still being detected in some marine systems downstream of countries that banned its use in the 1990s, indicating a 10-year or more time lag for this particular active substance to breakdown.

Aquatic biodiversity is a vital resource. Uncropped areas around water bodies – riparian zones – serve as important habitats that integrate communities of plants and animals from aquatic and terrestrial environments. Many terrestrial species that directly improve food production also rely on riparian zones. Such species include insects that develop in streams, emerge as adults and feed a range of predators, including birds and spiders. In turn these predators, sustained by prey from non-cropped land, can control pests on farmland. Importantly, there is a feedback loop between terrestrial and aquatic ecosystems, as the degradation of aquatic ecosystems can negatively impact populations on land and vice versa. Riparian zones are also beneficial for reducing pesticide run-off and soil erosion into adjacent streams, which can affect water quality and aquatic communities[168]. The presence and health of riparian zones adjacent to cropped habitats rely on the abatement of over spraying, spray drift and greater use of IPM tools, such as precision technology, to mitigate impacts of pesticides on these habitats. Increased implementation of the SUD should improve protection of riparian habitats over the next decade and provide an improving picture to 2030.

In terms of the IA scenario, studies have shown that legally binding pesticide targets in the F2F Strategy would reduce risks to water quality through the withdrawal or reduction in use of pesticides, however, it is likely that only a few pesticides may be responsible for the greatest risk, and these are likely to be addressed through existing Candidates for Substitution processes. The pesticide targets in the F2F Strategy may be unnecessary as a smaller overall, but more targeted reduction of certain substances could achieve the same environmental benefits.

7.4.1.4 *Air quality*

The application of pesticides through spraying equipment leads to minor parts of the applied quantity drifting away and contaminating the air. However, air quality beyond health risks for users and bystanders is not as widely discussed and considered as water quality and effects on pollinators or other species.

[167] Nödler K, Licha T, Voutsa D. (2013). Twenty years later–atrazine concentrations in selected coastal waters of the Mediterranean and the Baltic Sea. Marine pollution bulletin.70(1-2):112-8.

[168] Benton T, Bieg C, Harwatt H, Wellesley L, Pudasaini R. (2021). Food System Impacts on Biodiversity Loss Three Levers for Food System Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House.

Studies show the wide drift of pesticides in air and the persistence of substances that have been banned in the past. For example, the analyses from France[169] and Germany[170] find a ubiquitous presence of pesticides in air samples collected, even in natural parks and remote forest or mountainous areas, transported by wind across long distances [171]. Moreover, assessments of trends indicate that concentrations of substances such as DDT are not declining in air samples of land and sea[172].

The use of pesticides may therefore have effects on the environment and human health (see below in section 7.4.3) that are geographically and temporally more widespread that can be expected based on their local use.

Because of the demonstrated persistence in air, the baseline scenario sees little change in pesticide related air quality. However, improvements in low-drift pesticide application technologies are expected to reduce additional contamination when and where these technologies are taken up in substantial scale.

In the IA scenario, a stronger reduction of risk and use of pesticides and more hazardous ones is expected to reduce the risks to air quality by lowering the amount of new additions to air contamination. A focus on more hazardous substances that are related to bioaccumulation, mutagenic and reprotoxic effects through the non-renewal of Candidates for Substitution creates important parts of the benefits. For this reason, and because of the long persistence, a slow additional decline is achieved by legally binding pesticide targets as formulated in the F2F Strategy.

7.4.1.5 *Pollination services*

Pollination is the transfer of pollen between male and female parts of flowers enabling plant fertilisation and reproduction in crop production and wildflowers. Nearly 90% of the world's flowering plants require animal pollination[173], which is mostly performed by insects such as bees, flies and butterflies, but also includes some birds and bats. Pollinators can travel some distance, even migrate between countries transferring pollen to a separate population of plants of the same species, enabling cross-pollination, which maintains genetic diversity and species health[174]. Pollinators are not just responsible for boosting crop yield and supporting food security, they also enhance crop quality and, in turn, their economic value.

Pollinators are important from an economic perspective: in the EU, around 84 % of crops and 78 % of temperate wildflowers depend, at least in part, on animal pollination and an estimated

[169] ANSES. Proposition de modalités pour une surveillance des pesticides dans l'air ambient. 2017. Available at : https://www.anses.fr/en/system/files/AIR2014SA0200Ra.pdf

[170] Kruse-Plaß, M., Hofmann, F., Wosniok, W. et al. Pesticides and pesticide-related products in ambient air in Germany. Environ Sci Eur 33, 114 (2021). https://doi.org/10.1186/s12302-021-00553-4

[171] Kirchner, M., Jakobi, G., Körner, W., Levy, W., Moche, W., Niedermoser, B., Schaub, M., Ries, L., Weiss, P., Antritter, F., Fischer, N., Henkelmann, B. and Schramm, K.W. (2016). Ambient Air Levels of Organochlorine Pesticides at Three High Alpine Monitoring Stations: Trends and Dependencies on Geographical Origin. Aerosol Air Qual. Res. 16: 738-751. https://doi.org/10.4209/aaqr.2015.04.0213

[172] Mai, C., Theobald, N., Hühnerfuss, H. et al. Persistent organochlorine pesticides and polychlorinated biphenyls in air of the North Sea region and air-sea exchange. Environ Sci Pollut Res 23, 23648–23661 (2016). https://doi.org/10.1007/s11356-016-7530-3

[173] Potts SG, Imperatriz-Fonseca V, Ngo HT, Biesmeijer JC, Breeze TD, Dicks LV, Garibaldi LA, Hill R, Settele J, Vanbergen AJ. (2016). The assessment report on pollinators, pollination and food production: summary for policymakers. Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

[174] Science for Environment Policy. (2020). Pollinators: importance for nature and human well-being, drivers of decline and the need for monitoring. Future Brief 23. Brief produced for the European Commission DG Environment. Bristol: Science Communication Unit, UWE Bristol.

EUR 15 billion of the EU's annual agricultural output is directly attributed to insect pollinators[175]. In addition, some pollinators such as bees also provide food and additional income for rural families, in the form of honey and other by-products - thus, declining pollinator populations can impact on the sustainable livelihoods of rural families (FAO, 2009)[176]. With estimations of 50% of EU agricultural land being cultivated with crops that depend on pollination[177], negative impacts on agricultural yields could be a consequence.

Policy instruments for biodiversity have recently come into play with targets to 2030, and a specific strategy for pollinators was published in 2018 - The EU Pollinators Initiative. This sets strategic objectives and ten actions to 2030 for the EU Member States to reverse the decline of wild pollinators[178]. Two actions relating to this IA were highlighted in the European Court of Auditors special report on EU actions to protect wild pollinators in July 2020 including the need to better integrate actions to protect wild pollinators in the EU biodiversity conservation and agricultural policies; and, improve the protection of wild pollinators in the pesticides risk assessment process, including defining specific protection goals for wild pollinators [179].

As a result, in the baseline scenario, the European State of the Environment report predicts an improving outlook to 2030 for pollination services as a result of the EU Pollinators Initiative (plus green infrastructure investments in urban areas, for example) and recommendations to strengthen the environmental risk assessment of plant protection products for pollinators. However, additional action is needed to implement the Pollinators Initiative:

- Specific pollinator guidance is now part of Regulation 1107/2009 risk assessment and authorisation process through the assessment of acute risks to honeybees. A review is currently underway for incorporating chronic toxicity and larval toxicity for honeybees and acute toxicity for bumblebees, although it is noted that there are calls for greater realism in risk assessment from field and monitoring studies.
- Pollinator Initiative Action 5 to improve pollinator habitats on and around farmland was reviewed by the Commission in 2019 and showed that, for example, Ecological Focus Areas (EFA) under CAP had the potential to provide substantial benefits to pollinators, but wider adoption at a landscape-scale is needed (Cole et al, 2020)[180]. Targets in the EU Biodiversity Strategy for 2030 support pollinator-friendly farming landscapes, such as at least 10% of agricultural area must be under high-diversity landscape features, although this falls short. One prediction showed that 30% coverage of the Agri-Environment-Climate Measure under CAP is required to have population level impacts, requiring greater coverage from organic farming and high-diversity landscape features.

[175] European Commission. (2018), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment (COM(2018) 673 final, Brussels, 11.10.2018).

[176] Gallai N, Vaissière B. (2009). Guidelines for the economic valuation of pollination services at a national scale. Rome, FAO

[177] Maes, J., et.al., Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN, Publications Office of the European Union, Ispra, 2020, ISBN 978-92-76-17833- 0, doi:10.2760/757183, JRC120383. European Court of Auditors (2020). Press Release Luxembourg, 5 June 2020; Powney, G.D., Carvell, C., Edwards, M. et al. Widespread losses of pollinating insects in Britain. Nat Commun 10, 1018 (2019). https://doi.org/10.1038/s41467-019-08974-9

[178] https://ec.europa.eu/environment/nature/conservation/species/pollinators/policy_en.htm#:~:text=On%201%20June%202018%2C%20the,contribute%20to%20global%20conservation%20efforts.

[179] European Commission (2021). Report from The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions Progress in the implementation of the EU Pollinators Initiative COM/2021/261 final

[180] Cole LJ, Kleijn D, Dicks LV, Stout JC, Potts SG, Albrecht M, Balzan MV, Bartomeus I, Bebeli PJ, Bevk D, Biesmeijer JC. A critical analysis of the potential for EU Common Agricultural Policy measures to support wild pollinators on farmland. Journal of Applied Ecology. 2020 Apr;57(4):681-94.

- Pollinator Initiative Action 7 aims to reduce the impacts of pesticide use on pollinators. In 2018, the Commission discussed with Member States the possibility of integrating specific targets and measures for pollinators into the revised Member State national action plans (NAPs) under the Sustainable Use of Pesticides Directive (action 7A). However, within the review of NAPs published in November 2020, a low level of integration was reported. The Commission's Progress Report stated Member States must make more efforts to strengthen the provisions for pollinating insects in the NAPs.

These opportunities needed greater support and incentives for the implementation of landscape management for biodiversity enhancement and pollinator populations through the CAP, otherwise it may be concluded that the agricultural intensification under CAP either diminishes pollination services over the next decade or needs to be compensated through pollinator-specific objectives (and incentives) with a landscape perspective – and for substantial areas across Europe.

In terms of the IA scenario, reducing pesticide risk and use will relieve one key pressure from pollinators and therefore create a positive impact. However, it is unlikely that the additionality of the pesticide targets in the F2F Strategy will influence pollination services without corresponding policies in the CAP and other measures to implement the multiple actions of the Pollinator Initiative that address other pressures such as land use intensity and habitat diversity.

7.4.1.6 *Biological pest control*

Biological pest control is the use of living organisms to control pest populations. Much of the literature relates to organic farming, but is not exclusive as the use of biological pest control overlaps with IPM techniques (which include the use of pesticides) and with the environmental indicators for biodiversity and pollination services. Biological control relies on predation, parasitism and herbivory, or other natural mechanisms with active farmer's management. In organic farming, biological agents can be imported to locations where they do not naturally occur, or farmers can make a supplemental release of natural enemies, boosting the naturally occurring population[181].

Drivers for biological pest control in the SUD include IPM that encourages strategies for beneficial organisms is a primary driver for biological pest control. Cultural IPM tools rely on strategies to make the crop unattractive to pests, for example, diverting pest attack away from the crop to 'trap' planting. Other methods of control include crop rotation and mixed cropping. Mechanical and physical IPM controls include tillage, mulching and soil coverage or barriers, such as soil solarisation in southern European countries. However, these can sometimes be more harmful to ecosystem services, including beneficial organisms, than selective pesticides (for example, a comparative assessment of IPM crop protection methods in Italian tomato production[182]). Policy drivers that encourage biological diversity and natural or semi-natural habitat adjacent to crops, such as the EU Biodiversity Strategy, should influence biological pest control. Policy and other drivers for biological pest control are listed in Table 10.1.

It is important to mention that pest control organisms, when imported, can become pests themselves and some chemical pesticides (herbicides) are crucial in providing cost-effective controls for invasive species, particularly in urban areas or around transport infrastructure. Also, threats to agricultural and forestry production posed by pests and diseases will increase because of the extension of the geographical areas in which they are found due to climate change, as well as the

[181] Folnović, T. (2021). Best Practices for Pest Management in Organic Farm Production. Available at: https://blog.agrivi.com/post/best-practices-for-pest-management-in-organic-farm-production

[182] Deacon S, Alix A, Knowles S, Wheeler J, Tescari E, Alvarez L, Nicolette J, Rockel M, Burston P, Quadri G. (2016). Integrating ecosystem services into crop protection and pest management: Case study with the soil fumigant 1, 3-dichloropropene and its use in tomato production in Italy. Integrated environmental assessment and management. 12(4):801-10.

spread of newly introduced species and an overall rise in how abundant they are. For trees, greater frequency of drought, heat stress and waterlogging is likely to increase damage and deaths resulting from attacks by pests and diseases.

Evidence for the baseline scenario was drawn from the European Ecosystems Assessment and published literature. Crop provision as an ecosystem service was assessed by Maes (2018) by disentangling the yield generated by the (natural/semi-natural) ecosystem from yield generated by human inputs such as chemical pesticides. Analyses of changes over time are based on Eurostat statistics for 13 crop types including wheat, maize, potatoes and sugar beet, representing approximately 82% of the extent of all arable land in Europe. Maes (2018) estimated the contribution of ecosystems, such as biological pest control and pollination, to crop provision to be 21% of the total yield. This means that the remaining 79% of yield is derived from human inputs, including pesticides.

As Europe moves towards lower input pesticide regimes in plant protection, this ratio must be borne in mind as to whether all agricultural systems and situations can increase its biological pest control to maintain crop yield. Similar findings were reported by Bengtsson (2015)[183] who tested the relative importance of farming system (conventional vs. organic, human inputs, and management), landscape (field shape and landscape heterogeneity), and biological control of aphids by natural enemies (indicating a regulating ecosystem service) for barley yield on ten fields in central Sweden. Although biological control was related to increased yield, its contribution was relatively small (<20%). The farming system explained most of the magnitude and variation in yield (47% of the variation, of which 34% was unique). Landscape and biological control had the largest shared contribution to variation in yield (14%). Conventional farming management seemed to have a larger effect on yield than biological control, which could be interpreted as agricultural production should be further intensified to increase yields, but a high dependency on external inputs may not be sustainable, as is shown by the regulatory State of the Environment reports in this IA.

The importance of natural enemies for pest control is highlighted by Janssen and van Rijn (2021). They show that pesticides in agriculture often do not contribute to pest control *if* natural enemies of those pests are present. The authors reviewed other published research and found similar findings, such that pesticide applications generally result in short-term decreases of pest densities, but pest densities can subsequently resurge to higher levels than before. Conversely, a review by the JRC to inform assumptions in its CAPRI model assume a 10 to 50% loss in yield can occur when pesticide applications are reduced[184][185].

As with the other indicators, changes in land use and protection of wildlife refugia are fundamental. Several studies have shown that the maintenance of habitat heterogeneity – even in small quantities – is crucial for conserving biodiversity, ecosystem functionality and biological pest control

[183] Bengtsson JA. Biological control as an ecosystem service: partitioning contributions of nature and human inputs to yield. Ecological Entomology. 2015 Sep;40:45-55.

[184] Barreiro-Hurle, J., Bogonos, M., Himics, M., Hristov, J., Pérez-Domiguez, I., Sahoo, A., Salputra, G., Weiss, F., Baldoni, E., Elleby, C. Modelling environmental and climate ambition in the agricultural sector with the CAPRI model. Exploring the potential effects of selected Farm to Fork and Biodiversity strategies targets in the framework of the 2030 Climate targets and the post 2020 Common Agricultural Policy, EUR 30317 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-20889-1, doi:10.2760/98160, JRC121368.

[185] The assumptions were applied to cereals, oilseeds, vegetables, other arable crops and permanent crops

in agricultural lands. Hence, habitat complexity on a local scale is important for maintaining specialist predator populations that are important for pest control[186,187,188].

In the IA scenario, a reduction of 50% in the use of chemical pesticides and a 50% reduction in the most hazardous pesticides targets on the F2F Strategy would be additional to existing pesticide authorisation mechanisms. In theory, a reduction in the range and availability to use chemical pesticides should lead to a greater reliance on biological pest control. There is a potential benefit for this ecosystem service, but the transition will take time and its success will only be dependent upon other land use policies, which will need to go beyond the EU Biodiversity Strategy, to provide and attract habitats for natural enemies for pest control. It is uncertain that the supporting mechanisms for land use change will be in place to 2030 and a cautious "no change" is concluded for this IA.

7.4.1.7 *Conclusions on Environmental impact*

Table 7.2 Anticipated impacts on the environment

Environmental indicators	Baseline scenario to 2030	Pesticide related targets in F2F Strategy	Description
• Biodiversity and landscapes	↓	↓	The outlook in the baseline scenario to 2030 for all indicators is bleak with further declines in biodiversity and related ecosystem services according to reports by the European Environment Agency, the EU Ecosystems Assessment and researchers. The general conclusions are that the SUD, F2F and Biodiversity strategies, and the CAP provide useful direction for the agriculture sector, but require greater support, implementation and more ambition if they are to restore ecosystems and fully address the biodiversity crisis. The impact of pesticides and pesticide-related targets in the F2F Strategy contribute, and additional policies directed at protecting pollinators (e.g. EU Pollinator Initiative) and water quality and biological pest control (e.g. IPM) will help, but habitat loss has a greater impact, hence pesticide is only one part of the problem. The additionality of the pesticide targets in the F2F Strategy may have less of an impact when a more targeted reduction of a few substances could achieve the same environmental benefits, such as will be achieved through existing mechanisms under PPP Regulation 1107/2009.
• Soil quality	↓	↓	
• Water quality	↓	→	
• Air quality	↓	↓	
• Pollination services	→	→	
• Biological pest control	↓	→	

This impact assessment and future impact assessments would benefit from sustainability assessments being part of the regulatory process (either as part of the SUD or PPP Regulation 1107/2009) and for protection of the environment to include the following measures:

[186] Benton T, Bieg C, Harwatt H, Wellesley L, Pudasaini R. Food System Impacts on Biodiversity Loss Three Levers for Food System Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House. 2021:2021-02.

[187] Colloff MJ, Lindsay EA, Cook DC. Natural pest control in citrus as an ecosystem service: Integrating ecology, economics and management at the farm scale. Biological control. 2013 Nov 1;67(2):170-7.

[188] Rega C, Bartual AM, Bocci G, Sutter L, Albrecht M, Moonen AC, Jeanneret P, van der Werf W, Pfister SC, Holland JM, Paracchini ML. A pan-European model of landscape potential to support natural pest control services. Ecological Indicators. 2018 Jul 1;90:653-64.

- Expand the involvement of interdisciplinary experts in studies and regulatory decisions to improve its robustness and reliability in assessing the impacts on ecosystem services, underpinned by biodiversity, by capturing a variety of perspectives and opinions and providing a more rounded analysis and more informed policy decisions.
- Extend the Candidates for Substitution process to assess the long-term consequences of adjusting the pest control toolbox. Taking a herbicide as an example, consider the effects on the seed bank build-up, the impacts on soil-related ecosystem services (e.g. soil fertility, erosion, compaction, structure, biota health), the influence of IPM (e.g. crop rotation), as well as the changes over time of crop yield and the biodiversity of off-field habitats. Consider the use of pesticides alongside appropriate compensatory actions to mitigate potential impacts.
- Measure the influence of pesticides and alternative pest or weed management strategies to ensure that compensatory areas for nature conservation on farms are sufficient to meet Europe's total demand for ecological goods and services.
- The European Environment Agency[189] cites three areas of improvement, (i) wider uptake of sustainable management practices based on agroecological principles, organic farming and nature-based solutions; (ii) implementation and integration of EU policies in the upcoming strategic plans of the EU CAP 2021-2027; and (iii) more holistic approaches to facilitate the transition to sustainable agriculture. Achieving the reductions needed to reach environmental targets requires a combined approach, changing both agricultural practices and consumer demands, which is supported by a transition in food and energy systems. It is noted that our food production system place pressures on water, soil and biodiversity, yet around one third of all the food produced in the world is wasted. This amounts to some 1.3 billion tonnes every year. In the EU, approximately one fifth of our food production is lost or wasted. This is the equivalent of 88 million tonnes of food, at a cost of EUR 143 billion[190].
- Many researchers and food and agricultural organisations agree that reductions in pesticide usage/most hazardous pesticides alone will not be sufficient to address the climate and biodiversity crises, yet as a major European land user/owner, the agricultural sector has substantial opportunities to mitigate both crises. A paper by Chatham House[191] succinctly summarises the redesigning of food systems to restore biodiversity requires three 'levers' for reducing pressures on land and creating a more sustainable food system. The first is to change dietary patterns to reduce food demand and encourage more plant-based diets. The second is to protect and set aside land for nature, whether through re-establishing native ecosystems on spared farmland or integrating pockets of natural habitat into farmland (land sharing). The third is to shift to more sustainable farming. All three levers will be needed for food system redesign to succeed.

7.4.2 *Economic Impacts*

Economic indicators were selected to measure and value potential material economic impacts across the PPP and food value chains. To structure the discussion, the anticipated evolution of the selected economic indicators is analysed around the four categories listed below, however the connections

[189] https://www.agroecology-europe.org/new-report-of-the-european-environment-agency-eea-published-on-water-and-agriculture-towards-sustainable-solutions/

[190] European Union (2021). An Advocacy Toolkit for Nature Biodiversity loss, nature protection, and the EU strategy for nature

[191] Benton T, Bieg C, Harwatt H, Wellesley L, Pudasaini R. (2021). Food System Impacts on Biodiversity Loss Three Levers for Food System Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House. 2021:2021-02.

and feedback loops across them are acknowledged and explicit cross references are made as appropriate:

- Impacts on farm productivity and profitability;
- Impacts on PPP and PPP application value chain;
- Impacts on Food Value Chain; and
- Trade Impacts.

For each economic those indicators, we have explored the anticipated change brought through reaching the two F2F related policy targets. To support this process, a large body of literature has been identified and structured which has fed into the assessment.

A high-level summary of the main drivers of change and impact transmission is presented in sections 7.4.2.1 to 7.4.2.4. The full list of selected economic indicators and their anticipated trends for the period 2020 to 2030 over the baseline and in a scenario in which the pesticide-related targets announced int eh F2F Strategy are achieved, are presented in section 7.4.2.5. The full discussion on economic impacts is presented in Appendix 1, Section 10.2.

Another economic impact indicator from reducing the risk of pesticide use is the reduced need for treatment of water intended for human consumption. The case study "SUD provisions on water protection" has shown that the presence of pesticides in water bodies significantly increases the operational costs for drinking water purification since activated carbon filters have to be replaced more frequently. The IA study has not identified a published or recent value for the costs of pesticide removal from drinking water resources in Europe, but a PAN-Europe calculation of annual external costs of pesticide use in Germany placed the contamination of drinking water at a minimum annual value of EUR 65.45 million in 2005. Of this, the cost of water treatment was estimated to be EUR 8.95 million.

A study from France, estimated additional expenses of households, generated by this pollution linked to excess nitrogen and pesticides from agriculture would fall at least in a range between EUR 1.005 and 1.525 million , of which EUR 640 to 1.140 million are passed on to the water bill, accounting for between 7 and 12% of the national average bill. For households located in the most polluted communities, these additional expenses could reach 494 euros per household or 215 euros per person, i.e. an additional cost of almost 140% of the average water bill in 2006[192]. The reduction of pesticides in water bodies would avoid parts of those costs. However, this economic impact is of a smaller magnitude compared to the ones mentioned above and discussed below and is thus not discussed separately.

In the case of the SUD, most of the expected positive impacts are in those latter categories with environmental impacts including the expected improvement of a range of ecosystem services due to less pollution; and expected social impacts most notably including improved health. Social and environmental impacts are in most cases more difficult to quantify and monetise which makes a direct comparison in monetary terms challenging. However, through the approach taken in this report (i.e. illustrating expected trends on a range of indicators) it is shown that most of the social and environmental indicators are expected to take a positive development compared to the baseline. More detailed information on this is in section 7.4.1 on environmental impacts and 7.4.3 on social impacts.

[192] Olivier Bommelaer, Jérémy DEVAUX; Assessing water pollution costs of farming in France, Collection « Études et documents » of the Department for the Economics, Assessment and Integration of Sustainable Development, 2011. Available at: http://temis.documentation.developpement-durable.gouv.fr/document.html?id=Temis-0070550&requestId=0&number=5

7.4.2.1 *Impacts on farm productivity and profitability*

The dynamic baseline was based on the 2020-2030 EU Agricultural Market Outlook[193] commissioned by DG AGRI. Since the potential impacts of the F2F and BDS strategies on food production within the EU are not incorporated in the EC (2020) analysis, the baseline was further informed by a wider literature review which included policy reviews, additional modelling exercises, impact assessments and scientific and grey[194] literature[195] (see Appendix 1).

None of the policy reviews or impact assessments are conclusive, and none of them evaluate the impact of achieving the pesticide related targets announced in the F2F Strategy in isolation (all studies look at the combined effects of the F2F Strategy). Therefore, these assessments do not answer the additionality question: what changes in trends across the main economic indicators would be brought about by achieving the pesticide related targets announced in the F2F strategy, relative to the changes that are anticipated in the baseline. Moreover, model limitations and gaps in the evidence base in relation to pesticide dependence hinder the ability to make predictions in the baseline.

The homogenization created by agriculture at farm and landscape level has increased crop vulnerability to pests, disease and climate impacts (see Section 7.4.1 and Appendix 1, Section 10.1), and has in turn driven a greater use of precautionary measures such as chemical pesticides[196]. There is evidence in the literature of the potential presented by integrated pest management approaches, including crop rotation, to revert that trend by achieving a positive crop performance relative to conventional approaches[197]. Together with the implementation of novel technologies such as decision-support systems (DDS), precision agriculture with remote sensing combined with unmanned aerial vehicles, breeding of resistant cultivars and biopesticides, these approaches can reduce the dependence on PPPs thus limiting the negative productivity impacts of achieving the pesticide-related targets announced in the F2F strategy[198]. However, questions remain as to the impacts on food production and trade, and the economic implications of this transition for farmers and across the wider agri-food value chain.

The outcomes of previous analyses are based on different assumptions around farmers' behaviour and yield impacts, and the results obtained are highly variable and often contradictory[199]. Potential crop losses (i.e. total crop loss without any crop protection) and actual crop losses (i.e. those occurring when plan protection was conducted though PPP and/or by other cultivation measures)

[193] European Commission (2020). EU agricultural outlook; for markets, income and environment 2020 – 2030.

[194] Grey literature is a field in library and information science that deals with the production, distribution, and access to multiple document types produced on all levels of government, academics, business, and organization in electronic and print formats not controlled by commercial publishing i.e. where publishing is not the primary activity of the producing body. Examples of grey literature include: conference abstracts, presentations, proceedings; regulatory data; unpublished trial data; government publications; reports (such as white papers, working papers, internal documentation); dissertations/ theses; patents; and policies & procedures.

[195] For example, see Guyomard, Bureau et al. (2020), Barreiro-Hurle, et al., (2021), USDA (2020); COCERAL-PUNISTOCK (2021) and the Impact Assessment Study on EC 2030 Green Deal Targets for Sustainable Food Production currently being conducted by Wageningen University and Research on behalf of CropLife Europe

[196] Benton T, Bieg C, Harwatt H, Wellesley L, Pudasaini R. (2021). Food System Impacts on Biodiversity Loss Three Levers for Food System Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House. 2021:2021-02.

European Parliamentary Research Service (2020). Panel for the Future of Science and Technology. The future of crop protection in Europe. Study.

[197] see e.g. Lechenet et al., 2014; Colbach et al., 2020; Bareille and Dupraz, 2020

[198] European Parliamentary Research Service (2019). Panel for the Future of Science and Technology; Farming without plant protection products - Can we grow without using herbicides, fungicides and insecticides?

[199] Bareille, F. and Gohin, A., (2020). Simulating the market and environmental impacts of French pesticide policies: A macroeconomic assessment. Annals of economics and statistics, (139), pp.1-28.

are dependent on crop, geography, and wider farming practices, including fertilizer input, use of high-yielding varieties, irrigation, etc.[198]

The general tendency is for a reduction to be possible for (very) high actual PPP use, but not for low use operations. However, for those goals to be achievable, crop fields need to be better controlled for pests and diseases by adjusting PPP application schemes. Yield gains from PPP use are expected to be higher in high productive cropping systems relative to low productive cropping systems, where other culture measures and conditions (e.g. soil, climate) are often sub-optimal. Thus, changes to PPP use cannot be considered in isolation and optimisation of farming practices is required to reduce economic losses[200].

Additional pressures on yield will arise from climate change though increasing droughts, floods, storms and other extreme weather events, all of which pose a risk to European agricultural yields and farm productivity[201]. Climate change also brings implications for crop pests, as result of which crop pest movement and establishment is expected to worsen, as warmer winters in particular facilitate the introduction of unwanted organisms[202]. Cascading impacts in other areas of the world are expected to affect the distribution of global agricultural markets and supply chains, bringing agricultural income and food price implications to the EU[203] (Porfirio et al 2018, IPPC Secretariat, 2021) (these aspects are further discussed in sections 7.4.2.3 and 7.4.2.4).

Changes in farm income

Agricultural income in the baseline is uncertain, with an 11% increase projected by the 2020-2030 EU Agricultural Market Outlook and variable decrease percentages by crop category anticipated in the various policy reviews and impact assessments.

Reactions to changes in pesticide price or availability take place at two levels. At the intensive margin, farmers modify their variable input application for one given unit of crop-specific land. At the extensive margin, farmers modify their land use choices among different crops. Therefore, all other things being equal, an increase in pesticide price (and by extension, reduced pesticide availability) will lead to profit- maximizing farmers to not only (i) reduce their use of pesticide at the intensive margin for all crop types but also (ii) favour crops that are the least pesticide-intensive[204].

Thus, changes in farm income driven by a reduction in pesticide use and risk are complex and highly dependent on a range of interconnected variables – not least crop allocation choices, productive orientation and farm management practices, including the cost and pace of uptake of technological development and alternative control methods (e.g. biocontrol, mechanical weeding). Moreover, other external drivers such as climatic variability, incidence of pest and diseases, the evolution of oil prices, together with the extent and pace of adoption of IPM and the application of ecological principles in diversified systems, will influence pesticide dependence and the economic performance of farms.

[200] See Lechenet et al., 2014; Jacquet et al., 2010; Pimentel et al., 1993; EPRS, 2019

[201] Hristov, J., Toreti, A., Pérez, I., Domínguez, F. D., Fellmann, T., Elleby, C., ... and Bratu, M. (2020). Analysis of climate change impacts on EU agriculture by 2050. Publications Office of the European Union, Luxembourg, doi, 10, 121115.

[202] IPPC Secretariat. (2021). Scientific review of the impact of climate change on plant pests – A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems. Rome. FAO on behalf of the IPPC Secretariat.

[203] Porfirio, L.L., Newth, D., Finnigan, J.J. and Cai, Y., (2018). Economic shifts in agricultural production and trade due to climate change. Palgrave Communications, 4(1), pp.1-9.

[204] See Bareille and Gohin (2020).

7.4.2.2 *Impacts on PPP and PPP application value chain*

Agricultural inputs

Economic operators involved in the distribution and use of pesticides comprise agricultural inputs, machinery and services (e.g. agricultural contactors, extension services and crop marketing). Against this complex and varied upstream value chain, research is patchy (there are no indicators on the role of agricultural contractors on the European Farm Structure Survey for example) and no integrated analysis of all upstream products and services has been identified.

Overall, the European Commission (2020) projects nominal farm intermediate input costs to increase by 16%, reaching EUR 251 billion in 2030. The share of improved, lower-risk plant protection products is anticipated to increase in the baseline thanks to continuous investments in R&D to meet productivity gains and environmental standards. The demand for and production of biopesticides is also projected to increase in the baseline. Overall use of plant protection products is expected to slow down, thanks to better targeting and improved management through digital technologies, together with the projected increase in organic farming.

As previously noted (see discussion on pesticide dependence in section 7.4.2.1 and Appendix 1, Section 10.2), the distribution of costs is expected to vary significantly at farm level based on their productive orientation, economic structure and location. Changes to PPP use cannot be considered in isolation as attempts to reduce economic losses will lead to wider crop allocation choices and changes in productive orientation and farm management practices. Impacts on costs of agricultural inputs (and yield) are highly dependent on a range of interconnected variables, including the cost and pace of uptake of technological development and alternative control methods (e.g. mechanical weeding).

The impact of the reduced pesticide use in the EU for the plant protection products industry will be determined by the retail price and market share of new products. In response to the various policy changes and market disruptors, some companies have gone beyond consolidation and are already diversifying their services (e.g. investing in biologicals, collaborating with or acquiring companies in the digital space – farm management software and services – reformulating their products that will go off-patent into new marketable solutions, use of novel technologies to reduce time-to-market of new products and reduce R&D intensity)[205]. Achieving the pesticide related targets announced in the F2F strategy is expected to reinforce current trends.

Agricultural machinery

Agriculture in the European Union has traditionally been a labour-intensive sector characterized by a higher number of seasonal immigrant workers working on farm fields in the Member States. However, recent shortages of farm labour exacerbated by COVID-19 and Brexit is giving way to rise in wage rates, thereby allowing the farmers to adopt farm mechanization including tractors in the region. Furthermore, companies are heavily investing in technologies such as drones and driverless sprayers, with together with GPS mapping and simulation modelling are supporting the precise application of pesticides that results in higher yields and reduce environmental externalities. This is resulting in an unprecedented growth of precision farming. These developments, coupled with the rising importance of agriculture and a decreasing crop acreage, are likely to further enhance

[205] https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/agricultural-chemical-industry-outlook.html

mechanisation in the EU [206,207,208]. This development also offers opportunities for growth in the sector of agricultural services and equipment.

This trend is anticipated to be reinforced in a scenario in which the pesticide-reduction targets announced in the F2F Strategy are achieved, given the increase uptake of agri-tech applications.

Agricultural contractors

Contractors use a large amount of technology advanced machinery, supporting the use of innovative technologies for agricultural, rural and forestry activities (rather that the direct purchase of technology by farmers), as well as the employment of skilled workers. This in turn contributes to a better use of resources (by reducing costs and increasing profitability for farming activities) and environmental protection, including for small size exploitations[209]. Thus, the demand for and use of agricultural contractors is anticipated to significantly grow in the baseline.

Moreover, as with the agricultural machinery sector, the growth in demand for agricultural services is anticipated to be reinforced in a scenario in which the pesticide-reduction targets announced in the F2F Strategy are achieved, given the increased uptake of agri-tech applications.

Agri-tech

Agri-tech applications (i.e. technology and technological innovations to improve the efficiency and output of agricultural processes) are undergoing an unprecedented level of development. Spurred by the combination of global pressures resulting from climate change and a growing population with rising incomes, the agri-tech sector develops solutions aimed at increasing yield and reducing farm inputs and environmental costs, as a means to reduce productivity losses and improve food supply chain efficiency and access to/cost of finance to farmer. Particular developments are undergoing in[210]:

- Crop efficiency technology (smart), including agricultural data analytics, robots, drones, sensors, internet of thigs (IoT) monitoring, farm equipment sharing, efficient irrigation systems, soil and crop technology, smart phenotyping, satellite imagery.
- Biologically produced agrochemicals, micro- and nano-based bioengineering and bio-crops.
- The development of new breeding techniques (NBTs) speeding-up the development of resistant cultivars which could potentially have positive impacts on the environment and reduce costs and labour

The potential for uptake for smart technologies is highly influenced by farm size due to the large capital investments required. It is generally accepted that digitalisation will provide efficiency gains and resources saving, but it also presents limitations. The extent to which such limitations are addressed will determine the realization of its full potential and the avoidance of its negative effects. Overall, digitalization on its own will not result in better or sufficient protection for the environment and needs to be clearly linked to and guided by ambitious targets on pesticide use reduction, lower nutrition surpluses, or lower livestock density. Furthermore, if rebound and shifting effects are not avoided, efficiency gains could be partially or fully negated by additional consumption. On a different

[206] https://www.mordorintelligence.com/industry-reports/europe-agricultural-machinery-market

[207] https://www.mordorintelligence.com/industry-reports/europe-agricultural-tractor-machinery-market

[208] https://www.mordorintelligence.com/industry-reports/europe-agricultural-sprayer-market

[209] https://www.ceettar.eu/news.php?item=42

[210] https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-industrial-products/Deloitte-Tranformation-from-Agriculture-to-AgTech-2016.pdf

end of the spectrum, concerns about inequality, governance and pathway dependence raised by digital technologies have been raised by critics.

Micro- and nanotechnologies in particular are held back by a lack of regulations regarding their authorisation and introduction, as well as gaps in knowledge surrounding their potential risks, higher costs of production, and perceived lower effectiveness and lack of persistence (Vurro et al., 2019). Similarly, the EU's complex legal landscape and strictness of authorisation regulations have been linked to comparatively low European adoption rates of bio-crops, GMO products and products developed using new breeding techniques (NBTs), all of which have potential for significant growth should these regulatory barriers be eased (Zimny et al 2019).

Lastly, application of ecological principles is emerging as a strategy to increase the stability and resilience of crops, by increasing plant diversity (temporal, spatial and genetic) in and around cropping fields. Whilst the impact of this technique is difficult to quantify and variable, the beneficial effects of increased diversity on cropping systems is generally recognized (Letourneau et al, 2011). However, given that productivity trade-offs could trigger the need for the expansion of agricultural areas, a balanced approach focused on diversification strategies that improve the sustainability of conventional farming systems is required[211].

7.4.2.3 *Impacts on the Agri-Food value chain*

The food supply chain is highly consolidated, characterised by a power imbalance between strong agents operating in concentrated sectors in the downstream stages (i.e., industrial and retailing) and weaker agents in highly disaggregated sectors such as small farmers and consumers[212].

The performance of the agri-food value chain going forward will be strongly influenced by the evolving policy landscape and in particular the CAP, F2F and Biodiversity strategies, the continuous (re-) approval of active substances changing the availability of pesticides in different hazard categories (Regulation (EC) No 1107/2009) but also the growing global demand for food and inter and intra EU trade as shaped by the scope and nature of the underpinning trade agreements. Other strong influences and pressures arise from changes in technology and society from e-food and convenience retail to food quality and safety[213], as well as increased climatic and environmental variability, and conflicting demand for/reduced availability of land use and resources. Furthermore, dietary shifts in the EU will also likely require a range of interventions with varying degree of influence and will require action across the whole supply chain, including changing consumer behaviour.

The challenges these multifaceted drivers of change present to agri-food firms foster competition and innovation. By way of example, digitisation of the value chain would reduce information asymmetry through e.g., the emergence of on-line trading platforms for agricultural products, increasing transparency and traceability across the food value chain, and creating an environment in which actors can more easily buy and sell, compare prices and review and rate suppliers. In turn, innovation generates a series of inter-related markets in what is a continuously evolving and highly complex sector[214]. This transparency could also decrease margins for intermediaries and change distribution of value added across the food value chain, which since 2008 has seen an erosion of

[211] See Bellouin et al., 2019; European Parliamentary Research Service, 2020

[212] See Luca et al., 2018; van der Ploeg et al., 2016

[213] European Parliament (2016). Research for AGRI-committee - structural change in EU farming: how can the CAP support a 21st century European model of agriculture?. See: https://www.europarl.europa.eu/RegData/etudes/STUD/2016/573428/IPOL_STU(2016)573428_EN.pdf

[214] Djaniana, M.I and Ferreria, N., (2020). Agriculture sector: Preparing for disruption in the food value chain. McKinsey

the value share of agriculture relative to that of the downstream food processing and retail and services sectors.

Value added within each tier varies significantly across Member States and sectors, and farm size and overall business model play a critical role in the economic performance and overall resilience to shocks of holdings and enterprises. Whilst farmers are more exposed to supply and demand shocks of agricultural products given that both are highly inelastic, (i.e., a small reduction in demand or a small increase in supply can lead to a significant reduction in prices and, consequently, incomes - high income volatility; DG Agri, 2018), increasingly, the impacts of climatic events, environmental disturbances, technological developments and price volatility are not limited to local producers but spread through longer supply chains. With Europe's Food Tech companies represent almost 55% of the global AgriFoodTech ecosystem, the potential for disruption is high across areas ranging from food waste reduction to precision agriculture[215].

The extent to which the pressures and drivers listed will impact the performance of the agri-food value chain will differ for actors across each tier and even within each tier depending on their business model and context, both at Member State and EU level. The characteristics of the value chains themselves (i.e., whether driven by a large retailer, large processor, specialized high-quality retailer or large trader, short supply chains, or products with geographic indication) will determine the distribution of shocks across its various tiers.

However, little research has been conducted to examine the possibility of shock propagation, spill-overs and simultaneous shock events through food supply chains and their subsequent effect on consumption. This research gap limits the current understanding of the impact transmission in increasingly complex and globalized supply chains, although insights from resilience literature so far highlight the importance of production and source diversification and strengthening internal feedbacks[216].

The new CAP post-2020 will aim to address some of the challenges encountered by farmers and further bridge the value-added gap, however the extent to which it will succeed in reversing current trends and further counter environmental and economic pressures is uncertain, not least given the flexibility of implementation for Member States which may increase effectiveness but can also reinforce distributional differences.

At present, farmers follow a preventive approach to pest management that typically sees a suite of management tactics being implemented prior to planting and in the absence of pest data. However, dependency on pesticide use (and thus, the economic impact of achieving the pesticide related targets announced in the F2F strategy) can be reduced trough technological development and an agricultural model that supports low-cost farms. Furthermore, such a model would likely see an increase in agricultural jobs and gross value add for agricultural producers.

Social and environmental ambitions of the EU suggest a rethinking in the approach to farm concentration and growth, however the extent to which the new policies will support the development of smaller, low-cost farms or will continue to favour the accelerated growth of mega-farms is unclear. Overall, the impacts of these changes across each tier are difficult to predict and challenging to untangle from the potential impacts of achieving the pesticide targets announced in the F2F strategy, not least given the high complexity and variability presented in the various types of agri-food value chains.

[215] https://forwardfooding.com/blog/foodtech-trends-and-insights/food-tech-trends-europe-2020/

[216] Davis, K.F., Downs, S. and Gephart, J.A., (2021). Towards food supply chain resilience to environmental shocks. Nature Food, 2(1), pp.54-65

7.4.2.4 *Trade impacts*

Trade Outlook

The dynamic baseline was informed by the 2020-2030 EU Agricultural Market Outlook and the 2021 update of the JRC cumulative economic impact of trade agreements on EU agriculture[217]. It is acknowledged that the projections from these outlook reports are based on the OECD-FAO Agricultural Outlook 2020-2029, updated with recent global macroeconomic and market data[218]. The JRC trade outlook does not consider the potential impacts of the F2F, Green Deal and Biodiversity Strategies in its trade growth projections: a reduction in producer and consumer prices.

In addition, trade-related projections of the policy reviews and Impact Assessments discussed in section 7.4.2.3 were also considered. Whilst none of the studies reviewed are conclusive, and none of them evaluates the impact of achieving the pesticide related targets announced in the F2F strategy in isolation, they all point to potential impacts on the trade balance from increased dependency on imports (e.g. cereals, oilseeds) and a decline in exports (e.g. wheat, and specialised crops such as olives and wine). Any changes in food prices could have impacts on food availability and nutrition, with disproportionate effects on developing economies.

Notably, from the information available these policy reviews and impact assessments do not appear to incorporate demand side measures, nor some of the concluded but not implemented recent free trade agreements with the EU (e.g. with Mercosur and the updated FTA with Mexico, as well as trade agreements under negotiation (Australia, Indonesia, Malaysia, New Zealand, the Philippines, and Thailand) or the modernisation of the agreement with Chile. These agreements are expected to provide new trading opportunities and strengthen the trade balance and may counteract some of the impacts on trade from the Green Deal, F2F and Biodiversity Strategy.

It is very difficult to predict the extent to which the positive and negative trends will balance out based on current knowledge in the absence of a robust evidence base. Plus, the risks will be very much dependent on the different times at which each FTA will be ratified and will be definitively enforced, as well as on the nature and timescales of implementation of supplementary policies targeting demand side reductions, and any additional measures targeting coordination, knowledge transfer and capacity building in non-EU countries and in particular developing economies.

Trade-offs associated with a reduction in pesticide use in non-EU countries

Total import of agricultural products in the EU, in physical terms, is greater than that of total export[219]. This reliance on trade has led to a considerable externalisation of environmental pressures, and a dependence on ecosystem services located outside of EU MS's respective national boundaries[220]. Tensions among environmental and economic objectives in the EU policy are one of the drivers of evolution in the EU agricultural sector towards outsourcing of commodity production through trade. By outsourcing low-value commodity production (e.g. animal feed), the EU

[217] Ferrari, E., Chatzopoulos, T., Dominguez, I.P., Boulanger, P., Boysen-Urban, K., Himics, M. and Mâ, R., (2021). Cumulative economic impact of trade agreements on EU agriculture: 2021 update (No. JRC123037). Joint Research Centre (Seville site).

[218] While the OECD-FAO Agricultural Outlook published in 2021 presents a more recent outlook for the baseline period, and has been used to inform the analysis as relevant, this update has not yet been incorporated into the EU Agricultural Market Outlook and the 2021 update of the JRC cumulative economic impact of trade agreements on EU agriculture. These statistics have been added for context without further modification.

[219] Eurostat (2021). Extra-EU trade in agricultural goods. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Extra-EU_trade_in_agricultural_goods

[220] Renner, A., Cadillo-Benalcazar, J.J., Benini, L. and Giampietro, M., (2020). Environmental pressure of the European agricultural system: Anticipating the biophysical consequences of internalization. Ecosystem Services, 46, p.101195.

agriculture has been able to focus its activities on high-value product chains[221]. Thus, the trade balance has important environmental and human health implications on the distribution of impacts on biodiversity and on the integrity of EU ecosystems, as well as on the ecosystems of non-EU trade partners. By way of example, Cadillo-Benalcazar et al., (2020) have estimated the percentage mass of pesticides displaced due to the import of agricultural products to exceed the amount currently used in the EU.

Thus, achievement of the pesticide reduction targets announced in the F2F strategy is inextricably linked to the evolution of trade in agricultural commodities. What commodities are traded (in turn dependent on changes to the aggregate agricultural production and food prices, refer to section 7.4.2.3) and where and how they are produced (influenced by market demand, environmental and climatic conditions, the impact of non-technical barriers to trade and trade agreements, amongst other) will ultimately determine the internalised and externalised environmental impacts associated with food production (e.g. land use requirements, productivity, PPP and other input requirements, water demand, labour requirements). On the other hand, a direct or indirect reduction of pesticide use and risk in non-EU exporting countries – whilst limiting the externalisation or leakage of environmental impacts -– could lead to unintended economic and social consequences in exporting nations of reduced farm productivity, particularly in the face of increasing risks of shock events in developing economies.

Environmental pressures posed by the EU either through internal agricultural production or through trade in agricultural products are inexorably interlinked with the caloric intake and dietary profiles of its population (i.e., food availability and cultural factors). Thus, changes in consumption patterns can go a long way to reduce internal and externalised environmental pressures. For example, a dietary or policy driven reduction in meat consumption would reduce dependence on imports and/or the environmental pressures from the potential need to re-internalise some animal feed production (in addition to reducing GHG emissions), but would in turn have economic consequences for the EU producers of animal products[222].

On the other hand, and as previously discussed, higher costs for EU producers resulting from the implementation of the Green Deal, F2F and Biodiversity strategies could erode the competitiveness of EU-farming and the agri-food sector, deterring EU exports[223]. This has led to concerns about the level playing field for EU farmers and has driven calls for the application of the reciprocity principle to agri-food products from third countries, to ensure they have not been treated with PPP that are not authorised on the European single market[224]. In turn, these measures would also have social and economic consequences in the exporting countries through the potential deterioration of food prices and food availability, with negative impacts on the Sustainable Development Goals set out by the UN Agenda 2030. In response to these multi-dimensional and interlinked challenges and complexities, the European Economic and Social Committee has called for a more sustainable food policy with the aim of "providing healthy diets from sustainable food systems, linking agriculture to nutrition and ecosystem services, and supply chains which safeguard public health for all sections of European society"[225].

[221] See Cadillo-Benalcazar et al., 2020; Wang et al, 2018

[222] Cadillo-Benalcazar, J.J., Renner, A. and Giampietro, M., (2020). A multiscale integrated analysis of the factors characterizing the sustainability of food systems in Europe. Journal of Environmental Management, 271, p.110944.

[223] Bryan, John, (2020). Compatibility of EU trade policy with the European Green Deal. NAT/791-EESC-2020-EESC-2020-01349. Plenary session 554, Sep 16 – Sep 18, 2020.

[224] Roche Ramo Jose Manuel, (2021). Evaluation on Directive on the Sustainable use of Pesticides (Information Report), Plenary session 560, Apr 27 – Apr 28 2021.

[225] EESC (2018). Opinion on The Civil society's contribution to the development of a comprehensive food policy in the EU, OJ C 129, 11.04.2018, p. 18.

Health concerns associated with the handling and use of PPP are typically greater in developing countries due to the lower use of personal protective equipment. More specifically, inadequate use due to the inability of farmers to read the instructions, a lack of training on pesticide use, and inappropriate storage. The use of IPM, whilst promoted by the FAO and the EU, has been attempted by a number of countries - most notably Indonesia – however, the level of support required has been difficult to maintain due to its complexity and the resistance posed by farmers. Shocks from climate events and pandemics and challenges presented by the alternatives, together with the lack of business incentives or regulatory requirements for PPP manufacturers to make changes to their product portfolios, have further hindered the shift. Enhanced regulation and enforcement in developed as well as developing countries could encourage the shift to alternatives, however, constrains exist from a slow regulatory approval process, economic competitiveness of older, more harmful products and the influx of counterfeit imports and illegal mix and sale of local variants of pesticides for sale at affordable prices to small farmers. The shift to alternatives over the coming years will be insufficient to eliminate the use of chemical pesticides without compromising food security[226].

The above exemplifies the clear impact of food trade on pesticide use and the trade-offs between EU and non-EU agricultural production. To address these challenges and their associated economic, environmental and social impacts, it is imperative to integrate the Green Deal, F2F, Biodiversity and climate strategies along with the SDG goals into trade policies. Trade agreements and demand side measures can play an important role in reducing some key environmental and social pressures from agriculture, but they need to be balanced against social and economic impacts both within the EU and for its trading partners, and integrated as part of a sustainable food system. In addition, the role of trade in reducing vulnerability to climatic or institutional shocks (through a more distributed trade and production network) to reduce food insecurity should be considered.

Until green recovery and environmental considerations are more closely integrated with trade policies, land use changes resulting from demand pressures along with biodiversity degradation on non-EU countries are anticipated to continue a downward trend in the baseline. Similarly, pesticide use can be expected to continue to grow across many EU-exporting countries in the baseline, primarily Asia and the Americas, while some large agricultural producers like Canada have started following pesticide reduction strategies[227].

Achieving the pesticide targets announced in the F2F strategy is anticipated to lead to positive human health and environmental outcomes from a reduced environmental presence of pesticides and lower pesticide exposure for PPP users and food consumers. However wider environmental, social and economic trade-offs in the export countries may occur, with developing economies being most at risk of disproportionate effects. A reduction in productivity associated to a reduced availability of PPP and higher exposure to environmental or climatic shocks would increase food insecurity and the quality of the diets for those non-EU exporting countries affected, with unknown but important distributional effects in low-income economies, whilst also reducing the availability of exports. Depending on the development of demand as a result of e.g. dietary preferences, environmental impacts from land use change could potentially be caused if additional agricultural land is required to compensate for a reduced productivity.

[226] Sarkar, S., Gil, J.D.B., Keeley, J. and Jansen, K., (2021). The use of pesticides in developing countries and their impact on health and the right to food. European Union.

[227] FAO. 2021. Pesticides use. Global, regional and country trends, 1990–2018. FAOSTAT Analytical Brief Series No. 16. Rome

7.4.2.5 *Conclusions on Economic Impacts*

The tables below present an overview of the anticipated direction of change on the main economic indicators across the four categories, as informed by the discussion presented above and in Appendix 1, Section 10.2. Specifically, the baseline column in the table presents and informed judgement on the direction of travel of the selected indicators over the 10-year period, based on the evidence base available and presented above. The second column presents an informed judgement on the additionality of SUD to those indicators, in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved. In this context, an upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator. The addition of e.g. a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD revision is expected to reinforce the baseline trends, whereas e.g. an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends. However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, particular uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results.

Table 7.3. Anticipated direct and indirect impacts on selected indicators on farm productivity and profitability resulting from achieving the F2F targets on chemical pesticides, relative to the baseline

Indicators	Baseline	Pesticide related targets in F2F	Description
General production	↓	↓↓	The anticipated decrease in production is driven by an overall reduction in yield and, for certain cereals and oilseeds, also a reduction in cropped area. This trend is expected to be exacerbated in the scenario in which the pesticide related targets announced in the F2F strategy are achieved, given the potential additional impact on yield, however the distributional impacts would vary based on the productive orientation of the farm. It is considered unlikely that the deployment and uptake of alternative plant protection methods, including crop efficiency technology, biopesticides and NBTs will be conducted at the pace needed to avoid yield reduction resulting from a reduced pesticide use even in the baseline unless strong regulatory support is introduced, including economic subsidies to reduce capital expenditure barriers.
Agricultural producer prices	↑	↑↑?	The anticipated decrease in production is expected to induce production price increases. However, trade effects could influence producer prices over the medium to long term and limit the price increase.
Production costs	↑	↑↑?	Production costs could increase due to the additional mechanical control of weeds that would be required and other compensating mechanisms such as increased fertilizer use. Agri-tech technologies require large capital investments and thus the potential for uptake for smart technologies is highly influenced by farm size. This issue is particularly acute for innovations that give farmers access to data and not just mechanisation, where the long-run returns are often higher but less visible in the short-run and the value proposition of new technologies is less visible despite the savings in the long run and/or improvements in crop yields.
Gross margin	↓	↓↓?	The literature suggests that the increase in price will not be sufficient to outweigh the loss in yield despite lower costs from reduced inputs even when the cost of alternative plant protection technologies (IPM, mechanical weeding) are considered. Thus greater yield losses would lead to lower gross margin in the scenario in which the pesticide related targets announced in the F2F strategy are achieved.
Farm income	↔?	↓?	The expectation is that the CAP contributions would in general terms support current farm income levels on the average, and promote the adoption of agri-tech. However, the degree to which the negative economic impacts on farm productivity and profitability will be countered is unclear, particularly in the scenario in which the 50% reduction targets are achieved as the CAP budget requirements would be larger. When agri-tech is considered, despite the additional yield protection, the capital investment required for the technology will impact farm income.
Total value of crops	↓	↓↓?	At aggregate level, the loss in yield and reductions in crop areas are not expected to be compensated by basic price increases, resulting in an overall loss in the total value of crops output (at basic prices)

Note: anticipated trends depicted by arrows.

? denotes uncertainty in the projection

Table 7.4. Anticipated direct and indirect impacts on selected indicators of the PPP and PPP application value chain

Indicators	Baseline	Pesticide related targets in F2F	Justification
Pesticide use	↓	↓↓	Achievement of the pesticide related targets announced in the F2F Strategy is expected to reinforce the current trend on pesticide use reduction.
Agrochemical suppliers (PPP)			
Number of enterprises	↓?	↓?	Consolidation of local and regional players in the European agrochemicals industry will likely see the number of enterprises to continue to diminish, whereas the diversification and servitisation of the agrochemical suppliers is expected to continue. It is anticipated that agrochemical companies will move to R&D in the biopesticides sector, given the lower costs relative to R&D for chemical pesticides. On the other hand, the lack of intellectual property protection mechanisms on bioproducts may limit investments by multinational in the field. Achieving the pesticide related targets announced in the F2F strategy will further reinforce the trend rather than creating an additional disruption.
Employment (FTE)	↓	↓?	The above trends could accelerate the loss of employment in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved, but the outcome will be dependent on wider employment demand resulting from the ongoing diversification.
Agricultural machinery			
Number of enterprises	↑?	↑↑?	When considering the outlook for agricultural machinery, assumptions in relation to crop type and use of plant protection products in the baseline are critical, as is the choice and cost of farm management practices and alternative control methods (e.g. mechanical weeding). Overall, a reduction in pesticide use is expected to be enabled by the increased uptake of precision agriculture and alternative pest control methods including mechanical methods.
Number of enterprises	↑?	↑↑?	The increase in demand for agricultural machinery driven by enhanced mechanisation trends in the baseline is expected to lead to a growth in employment for the sector. This growth could be further enhanced in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved, with the uptake of agri-tech.
Agricultural services (PPP application, training, etc.)			
Number of enterprises	↑?	↑↑?	A reduction in pesticide use is anticipated to further reinforce the growth in demand for agricultural contractors to support the uptake of technology advanced machinery, including precision agriculture, provided that the cost gap is addressed either though higher food prices and/or subsidies/additional funding through the new CAP.
Employment (FTE)	↑?	↑↑?	The increase in demand for agricultural services driven by enhanced mechanisation trends in the baseline is expected to lead to a growth in employment for the sector. This growth could be further enhanced in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved, with the uptake of agri-tech.

Note: anticipated trends depicted by arrows.

? denotes uncertainty in the projection

Table 7.5. Anticipated impacts on selected indicators of the agri-food value chain

Indicators	Baseline	Pesticide related targets in F2F	Justification
Price volatility	↑	↑↑	Price volatility is projected to increase owing to the increasing global demand for food driven by population growth, the growing economic prosperity of developing economies and changes in dietary shifts away from grains to meats and other calorie-rich foods, increasing demand for biofuels, the slowdown in productivity growth in agriculture (due to natural resources/land constraints), poor harvests in some major producing countries caused by climate change and shock events; increasing input cost (e.g. fertilisers, plant protection products) and their link with price trends in other commodities such as energy. Volatility is expected to further increase in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved, due to the anticipated decrease in EU production and greater exposure to shocks.
Agricultural production			
Number of holdings	↔?	↔?	The trends in agricultural labour, farm number and size, producer prices and value add remain uncertain in the baseline given the evolving policy landscape and the lack of consensus and evidence base about its impacts. The extent to which the new CAP will reduce the erosion of the low-cost small farms is unclear, but the negative trend in the number of farms is expected to reduce based on the assumption of greater support for social and environmentally sustainable holdings. In particular, the anticipated decrease in the number of conventional farms is expected to be largely offset by the increase in organic farms. In this scenario, changes induced by achieving the pesticide targets announced in the F2F strategy are expected to be limited, although it could provide an advantage to small, lower input farms.
Size of farms	↔?	↔?	
Employment (FTE)	↔?	↔?	The above-described baseline developments would limit the decline in the volume of agricultural labour to some extent, although gains are expected to be countered by greater mechanisation and efficiency in the sector. Changes induced by achieving the pesticide targets announced in the F2F strategy are not expected to have a significant impact on employment.
Agricultural producer prices (at farm gate)	↑	↑↑?	The rate of increase of producer prices could be reinforced by a reduced and increasingly volatile supply exacerbated by a reduction in pesticide use (refer to section 7.4.2.1). The extent to which these supply pressures will be balanced out by a demand side measures (i.e., reduction of food loss and food waste) and more sustainable trade agreements (refer to section 7.4.2.4) is unclear.
Value added	↑?	↑?	The average agricultural share of the value add could increase due to greater policy support, reinforced by a greater share of organic farming and short value chains, however this gain will not be equally distributed across all actors in the agricultural production tier. In this scenario, changes induced by achieving the pesticide targets announced in the F2F strategy are expected to be limited.
Food processing			
Number of enterprises	↑	↑	The evolution of the food processing indicators is not anticipated to be widely impacted by achieving the pesticide targets announced in the F2F strategy beyond the potential impacts on producer and wholesale prices. However, given the ability of these sectors to pass higher costs on to consumers, the latter could see the biggest share of the impact on food prices. In particular retailer/supplier power can see an asymmetric transmission of costs to producers and, in the long term, consumers
Employment (FTE)	↑	↑	
Domestic producer prices	↑	↑?	
Value added	↑	↑	

Indicators	Baseline	Pesticide related targets in F2F	Justification
Food distribution			
Number of enterprises	↔	↔?	The evolution of the food distribution/wholesale indicators is not anticipated to be widely impacted by achieving the pesticide targets announced in the F2F strategy beyond the potential impacts on producer and wholesale prices. However, given the ability of these sectors to pass higher costs on to consumers, the latter could see the biggest share of the impact on food prices. In particular retailer/supplier power can see an asymmetric transmission of costs to producers and, in the long term, consumers
Employment (FTE)	↑	↑	
Wholesale prices	↑	↑?	
Value added	↑	↑	
Consumers			
Number of consumers	↔	↔	No material changes in population (for the purposes of this assessment) are anticipated in either scenario.
Consumer prices	↑	↑↑?	Consumers could see the biggest share of the impacts downstream in the agri-foood value chain due to asymmetric price transmission from processors and distributors. Ultimately, the impact on consumers will be closely linked to the changes on crop type and yield in the aggregate (refer to section 10.2.2) along with wider impacts on the sustainability of supply arising from the concentration and subsequent bargaining power of the retail grocery market and the evolution of the trade balance (refer to section 10.2.5).

Note: anticipated trends depicted by arrows.

? denotes uncertainty in the projection

Table 7.6. Anticipated direct and indirect impacts on selected trade indicators

	Baseline	Pesticide related targets in F2F	Justification
Effects on trade			
EU agricultural import demand	?	?	The evolution of trade in the baseline remains uncertain given the evolving policy landscape and the lack of evidence base about its impacts when current trade agreements and demand side measures are considered. There is a risk for the pesticide targets announced in the F2F strategy to reinforce negative pressures on trade but the extent to which these will be responsible for limiting the projected growth in the trade balance or even lead to a reduction in trade cannot be established, particularly given the synergistic effects between the different policies. The distributional effects, whilst central to the discussion, require a granular analysis and could not be established as part of this assessment. It is important to note, however, that even if the overall EU imports (in tons or value) may remain stable, the mix of goods and the percentage share across exporting countries may change. The consequences of any potential changes will be inversely proportional to the adaptation period and the measures established by the EU to support the transition in developing economies (e.g., access to low-cost alternatives, capacity building, knowledge sharing, support in establishing an efficient pesticide re-evaluation process in developing countries).
EU agricultural export	?	↓?	
Trade balance	?	?	
Environmental, economic and social impacts resulting from changes in EU trade with developing economies			
Farm productivity in non-EU countries	?	?	Given the uncertainty about trade flows and the increasing frequency of shock events resulting from climatic events and biodiversity loss, the indirect environmental, economic and social impacts in non-EU developing nations exporting to the EU are difficult to predict and challenging to untangle from the combined effects of the mix of policies driving the transition. if unmitigated, any direct or indirect reduction in PPP availability in developing countries could have implications on farm productivity, food availability and, ultimately, food prices and the diet in the populations of those countries and could also have consequences for EU consumers
Food prices (non-EU consumers)	?	↑	
Food availability (for non-EU consumers)	↓	↓↓	
Indirect land use changes	↑	↑↑	Environmental benefits associated to a reduction in pesticide concentrations could be offset by biodiversity impacts resulting from land uses changes to address yield losses and/or to meet greater demand for certain crops.
Biodiversity degradation	↑	↑↑	
Pesticide exposure by farmers	↑	↑?	It is unlikely that achieving the pesticide targets announced in the F2F strategy will drive a meaningful reduction on pesticide exposure on their own. For a quantifiable reduction in pesticide exposure by farmers and consumers to be achieved, additional measures are expected to be required to improve pesticide re-registration, handling and use, and reduce the influx of counterfeit imports and illegal mix and sale of local variants, whilst ensuring low-cost alternatives are available.
Pesticide exposure by consumers	↑	↑?	

Note: anticipated trends depicted by arrows.

? denotes uncertainty in the projection

7.4.3 *Social and Health Impacts*

Health related indicators were selected to measure and value a set of social impacts across the food value chain. The following indicators are analysed:

- Impacts on exposure to pesticide by consumers;
- Impacts on exposure to pesticides by users;
- Impacts on exposure to pesticides by bystanders; and
- Impacts on diets and nutrition

For those indicators, we have explored the anticipated change brought by reaching the two F2F pesticide targets.

7.4.3.1 *Exposure by consumers through pesticide residues in food and beverages*

It is a regulatory requirement[228] for all EU countries to monitor food for pesticide residues, this monitoring exercise is undertaken by conducting specific surveys each year. These surveys identify whether food that is consumed in the EU is legally compliant by ensuring that the pesticide residues found is within the Maximum Residue Level (MRL) and has been approved for use in the EU Member States. The MRL is defined by the European Commission as ''*the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly (Good Agricultural Practice)*''.

In a baseline scenario, it is expected that no change to the SUD would mean that MRL exceedances remain on a similar trend line as in recent years. MRL exceedance rates have not increased or decreased between years, it varies but mainly due to sampling of different types of products and produce in the EU. The presence of multiple residues in a single sample is compliant with the current legislation, but each individual residue level must not exceed its respective MRL. The MRLs set for single substances do not take into consideration the presence of mixtures in real-life conditions[229,230] and the current measures to protect human health do not adequately address potential for mixture effects. It has been shown that combinations of chemicals present at even low levels may contribute to the overall risk of adverse health effects such as cancer and reproductive toxicity.

Despite the regulatory measures currently in place in the EU the potential for MRL exceedances to occur remains. It is worth noting here that these MRL exceedances are a snapshot in time of the situation of pesticide residues in those products that are the most widely consumed in the EU. The MRLs are an estimation of the expected residue distribution calculated using statistical methods. Therefore, in the absence of policy change, it is anticipated that approximately 1% of MRL exceedances is to be expected even if good agricultural practices are fully respected. Consumer exposure to pesticides through consumption of food is unlikely to change significantly in the absence of policy change.

It should be noted that while MRLs can be used as indicators of exposure to pesticides in food, MRL exceedances do not correlate to risk to consumers from pesticides. Occurrence of adverse health effects as a result of exceeding the MRL or health-based guidance value is not easily measurable

[228] Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC (Text with EEA relevance)

[229] World Health Organization. Public Health Impact of Pesticides Used in Agriculture. England: World Health Organization; (1990).

[230] Kortenkamp A. Ten years of mixing cocktails: a review of combination effects of endocrine-disrupting chemicals. Environ Health Perspect (2007) 115:98–105.10.1289/ehp.9357

due to the vast number of confounding factors and lack of a suitable or harmonised monitoring system in place across the reporting countries.

The pesticide related targets of the F2F strategy include a reduction in the use and risk of chemical pesticides as well as ta reduction of the use of the more hazardous pesticides by 2030. The realisation of these targets is expected to reduce the levels and incidence of exposure to pesticides in food and beverages. Therefore, a reduction in the use and risk and move to the use of less hazardous chemical pesticides should reduce overall exposure. This would inevitably decrease the potential for adverse health effects caused by the presence of pesticides in food. However, it is not possible to quantify the health impact of reduced exposure in a meaningful manner, based on current knowledge and data availability.

7.4.3.2 *Exposure by pesticide users from pesticide handling and application*

Exposure to pesticides occurs during handling and application activities. Users of pesticides include both occupational and general use. Occupational exposure includes agricultural workers, such as farmers and professional applicators of pesticides[231][232]. In the EU, farmers and farm workers are likely to face a relatively greater risk of exposure to pesticides compared to the general population. There can be a number of ways individuals can become exposed to pesticides during use, such as those who mix, load, and spray pesticides can be exposed due to spills and splashes, direct spray contact as a result of faulty or missing protective equipment, or spray drift. However, exposure can also occur from activities that are not directly related to pesticide use, these may include for example working in the vicinity that has been treated with pesticides. Therefore, it is conceivable that those who work with pesticides are likely to have the greatest exposure. In addition to exposure by normal usage, exposure may also occur as a result of accidental spills of chemicals, leakages, or faulty spraying equipment.

There is no available data to inform a baseline on the exposure to pesticides among professional users. While Member States collect data on acute pesticides poisoning, the information is not publicly available. Global studies, however, indicate a low but existing level of poisonings for professional users in Europe[233]. There is a high level of uncertainty around the quality and reliability of data currently available for exposure of workers to pesticides. This is further exacerbated by the lack of data on contact of pesticide handlers with treated crops, where exposure may be different depending on the extent of time after pesticide application.

In summary, the baseline exposure to pesticides and the potential for health effects associated with this exposure is greatly influenced by confounding factors and the lack of reliable data on usage. There is likely to be a decrease in pesticide exposure by professional users during baseline as more hazardous pesticides are withdrawn from use or different pesticides are used as part of the organic farming initiative or IPM measures.

Reaching the F2F targets on pesticides have the potential to lower exposure to pesticide handlers (short term and long term). This would likely have an impact on the health of these users given that there will be a reduction in the use of hazardous pesticides. However, it is not possible to quantify the health impact of reduced exposure in a meaningful manner, given that while there is

[231] Woodruff T.J., Kyle A.D., Bois F.Y. (1994). Evaluating health risks from occupational exposure to pesticides and the regulatory response. Environ. Health Perspect.102:1088–1096. doi: 10.1289/ehp.941021088.

[232] Maroni M., Fait A., Colosio C. (1999). Risk assessment and management of occupational exposure to pesticides. Toxicol. Lett. 1999;107:145–153. doi: 10.1016/S0378-4274(99)00041-7.

[233] Boedeker, W., Watts, M., Clausing, P. et al. (2020). The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. BMC Public Health 20, 1875. https://doi.org/10.1186/s12889-020-09939-0
Patel S. and Sangeeta S., (2019). "Pesticides as the Drivers of Neuropsychotic Diseases, Cancers, and Teratogenicity among Agro-Workers as Well as General Public."

data on acute poisoning events in pesticide handlers there is no such data from the normal use of pesticides in professional users.

7.4.3.3 *Exposure to bystanders from pesticide application*

Bystanders are people who are not involved in working with pesticides but may be located within or directly adjacent to the area where product application is in process or has recently been completed. Bystanders are assumed to be exposed during a short period of time and take no action to avoid or control exposure. Exposure can include during or after the application of pesticides by the dermal and inhalation routes of exposure. Oral exposure may occur in infants and toddlers through accidental hand-mouth transfer.

Exposure of bystanders to pesticides has been linked to adverse health outcomes such as reproductive effects or cancer[234]. For example, diabetes has been linked to exposure to organochlorine pesticides[235,236,237]. However, a causal link between exposure and adverse health effects is confounded by a lack of data on exact exposure information, and the evidence available is not conclusive.

With the continued implementation of SUD and F2F, related actions such as increase in organic farming and IPM means that there should be a reduction in baseline bystander exposure. For instance, IPM introduces strategic and targeted use of pesticides using optimised spraying technology that would reduce the loss of pesticides to spray drift. Given the lack of information to form a causal association between bystander exposure and linked adverse health effects, it is difficult to form a meaningful baseline. Added to this the heterogeneous representation of the bystander population that exhibit inter-individual variation means that it complicates efforts to form a baseline of bystander exposure.

It is difficult to predict the impact that the pesticide related targets in the F2F strategy will have on bystander exposure, even more in the context of further distances between use and recipient as presented in the assessment of air quality (section 7.4.1.4). This is mainly due to the difficulty in knowing the exact exposure level to the pesticide as this is often not measured, the heterogeneity of the exposed population (including vulnerable subpopulations) and exposure via other routes. It may be helpful that in addition to the changes in pesticide use and use of less hazardous substances there should be a concerted effort in understanding bystander exposure levels. One possible method for determining this could be by biomonitoring for exposure. However, given the various ways in which pesticides are known to act means that this would involve being able to detect the parent pesticide, its metabolite, or reaction product in biological media. This can be invasive in case of determining exposure in blood or urine and measurement depends on the metabolic capacity of the individual, half-life of the pesticide and its metabolites as well as availability of biological reference values. The HBM4EU data reported urinary levels of certain pesticides and their metabolites, but it

[234] Shirangi, A.; Nieuwenhuijsen, M.; Vienneau, D., 2009. Bystander Agricultural Pesticides Exposure and the Risk of Adverse Reproductive Outcomes: A Review of the Literature, Epidemiology: November 2009 - Volume 20 - Issue 6 - p S184 doi: 10.1097/01.ede.0000362622.69114.30

[235] Cox, S., Niskar, A., Narayan, V., Marcus, M., 2007. Prevalence of self-reported diabetes and exposure to organochlorine pesticides among Mexican Americans:hispanic health and nutrition examination survey, 19821984. Environ. Health Perspect. 115 (12), 1747e1752. https://doi.org/10.1289/ehp.10258.

[236] Azandjeme, C.S., Bouchard, M., Fayomi, B., Djrolo, F., Houinato, D., Delisle, H., 2013. Growing burden of diabetes in sub-saharan Africa: contribution of pesticides? Curr. Diabetes Rev. 9 (6), 437e449. https://doi.org/10.2174/15733998113099990078

[237] Evangelou, E., Ntritsos, G., Chondrogiorgi, M., Kavvoura, F.K., Hernandez, A.F., Ntzani, E.E., Tzoulaki, I., 2016. Exposure to pesticides and diabetes: a systematic review and meta-analysis. Environ. Int. 91, 60e68. https://doi.org/10.1016/j.envint.2016.02.013.

was not possible to distinguish between exposure from residues in food versus non-dietary exposure[238].

7.4.3.4 *Impacts on diet and nutrition*

The influence of food cost on the quality of diet can exacerbate social inequalities[239]. Life expectancy can be increased with a balanced and varied diet. Poor nutrition caused by unhealthy diet is contributing to the burden of non-communicable diseases such as cardiovascular diseases, type 2 diabetes and some types of cancers. Poor nutrition is being blamed on excessive consumption of energy, saturated fat, trans fats, sugars and salt, as well as low consumption of vegetables, fruits and whole grains in EU Member States[240].

The production and yield of crops in Europe is expected to increase during baseline to support the increasing needs by consumers. Government-led initiatives to increase affordability and availability of healthy food options, would be expected to offset the predicted rise in costs such as feed (for animal production), seed, energy and fertiliser. However, an increase in organic farming and the continued implementation of IPM may result in increased cost of food as food producers attempt to recoup costs associated with the new systems and this may influence the availability of crops potentially pushing cost of food higher.

Achieving the pesticide-related targets announced in the F2F strategy may have a negative impact on yield and production. With a reduction in pesticide use, food production would be expected to decrease whilst the market adjusts to new techniques and approaches and resultantly food prices would rise.

Increases in food prices force people to adjust as consumer purchasing power decreases and this is likely to have a negative impact on household dietary choices and nutrition. Food price in the EU is also being impacted by an increase in global prices of foodstuff such as cereals[241].

In a study undertaken to explore the impact of food price policies on the nutritional quality of food baskets chosen by low- and medium-income households showed that low-income individuals selected less expensive and less healthy baskets than medium-income ones[242]. In a systematic literature review of publications linking food prices, dietary quality, and socioeconomic status revealed that foods of lower nutritional value and lower-quality diets were likely to be selected by groups of lower socioeconomic status because they cost less per calorie[243]. This may then lead to widening socioeconomic disparities given the higher cost of consuming a healthy diet.

[238] https://www.hbm4eu.eu/the-substances/pesticides/

[239] James WP Nelson M Ralph Aet al. . Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. BMJ. 1997;314:1545–1549.

[240] https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/nutrition

[241] https://op.europa.eu/en/publication-detail/-/publication/57d860fd-9cc9-11eb-b85c-01aa75ed71a1/language-en/format-PDF/source-207940309

[242] Darmon, N., Lacroix, A., Muller, L. et al. Food price policies improve diet quality while increasing socioeconomic inequalities in nutrition. Int J Behav Nutr Phys Act 11, 66 (2014). https://doi.org/10.1186/1479-5868-11-66

[243] Darmon, N., Drewnowski, A., Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis, Nutrition Reviews, Volume 73, Issue 10, October 2015, Pages 643–660, https://doi.org/10.1093/nutrit/nuv027

7.4.3.5 *Conclusion on Social and Health impacts*

Table 7.7 Anticipated social and health impacts

Indicators	Baseline	Pesticide related targets in F2F	Description
Exposure by consumers			
• Reduction in MRL exceedance	–	↓	The anticipated reduction in the MRL exceedances is driven by the reduction in the use chemical pesticides and reduction of the use of the more hazardous pesticides by 2030 therefore the likelihood of the presence of pesticides in the food that is consumed is expected to decline.
• Pesticide exposure by consumers	?	↓	The anticipated decrease in pesticide exposure by consumers is linked to to the reduction in the use chemical pesticides by 2030 therefore the likelihood of the presence of pesticides in the food that is consumed is expected to decline.
• Exposure to mixtures		↓?	The reduction of pesticide use by 2030 will be unlikely to lower the risk of adverse health effects caused by mixtures of pesticides given that mixture effects are currently not addressed in the EU.
Exposure by pesticide users			
• Pesticide exposure by professional users	↓	↓	A reduction in the use of pesticides and move to the use of less hazardous chemical pesticides should reduce overall exposure by professional users.
• Incidence of adverse health effects (acute and chronic) from exposure	↓	↓	A reduction in the use of pesticides and move to the use of less hazardous chemical pesticides should reduce overall exposure by professional users, which in turn would lower the likelihood of the incidence of adverse health effects that are attributed to pesticide exposure.
• Exposure to organic-approved pesticides	↑	↑	Exposure to organic-approved will increase regardless of the pesticide related targets in F2F. This is due to requirement of 30% of all food production in the EU to be organic by 2030, which may change the type of pesticides that handlers are exposed to as they move to those pesticides that are permitted under organic farming rules.
Impact on diets and nutrition			
• Cost of food	↓		With a reduction in pesticide use, food production would be expected to decline whilst there is an adjustment period and resultantly food prices would rise.
• Health-based government initiatives	–		It is unlikely that the government-led initiatives for health interventions in relation to diet and nutrition will be impacted by the pesticide related targets in F2F.
• Adverse effect on diet and nutrition	↓	↓	Increases in food prices force people to adjust as consumer purchasing power decreases and this is likely to have a negative impact on household dietary choices and nutrition.

8. Assessment and comparison of combinations of elements

Based on the assessment of elements of options, presented in Appendix 2, combinations of these elements are assessed on their response to the problems identified and discussed in Chapter 2. In summary, those problems are:

- The uneven implementation of current SUD provisions in the Member States, including:
  - The varying and limited operationalisation of the IPM principles
  - The varying and limited effectiveness of NAPs
  - The varying and limited implementation of the SUD concerning testing of pesticide application equipment
  - Potential for improved advisory services
- The missing alignment of the SUD with the ambition defined in the F2F Strategy and the related need to further reduce the current use and risk of pesticides
- Varying and limited monitoring and data availability, causing a lack of knowledge on actual pesticide use and risk
- Missing account of new technologies in the SUD.

Firstly, this chapter will discuss the selection of elements based on their level of ambition in three options:

- The least ambitious option, combining the elements defined at least ambition (LE),
- The medium ambitious option, combining the elements defined at medium ambition (ME), and
- The most ambitious option, combining the elements defined at most ambition (MO).

Secondly, relevant combinations of options across the levels of ambition will be discussed and assessed.

8.1 Options based on their level of ambition

8.1.1 Least ambitious option

Combining all elements of least ambition would result in a policy option that mainly provides further clarifications and guidance on the current SUD provisions (on e.g. IPM principles, NAPs, standards for testing of pesticide application equipment, or the ban of aerial spraying from drones), together with a few additional elements, such as expanded training requirements for advisors, restrictions for non-professional users to purchase more hazardous pesticides and the promotion of new technologies. The pesticide related targets of the F2F Strategy would remain aspirational, as in the status quo.

The assessment of the impacts of the elements finds that this option would lead to low costs as the elements would be close to the baseline and continue to leave Member States high flexibility in their approach to ensuring sustainable pesticide use in light of the F2F targets. However, this option would not be an effective response to the problems, as the limitations of the current approach, in particular in relation to data availability and varying implementation would likely persist. Therefore, even though the additional costs are expected to be low, the efficiency is also low.

8.1.2 Medium ambitious option

A combination of medium ambitious elements would see increased action on reducing the use of more hazardous pesticides through (1) a requirement for prescription systems in Member States for the purchase of such pesticides, and (2) a ban of the use of these pesticides in sensitive areas.

This would be complimented with mandatory electronic record keeping on IPM implementation together with annual reporting of Member States as well as increased testing of new PAE and harmonisation of drift reduction tests. Spraying with drones would in the future be possible without derogations according to further legislation to be drafted based on scientific findings. A NAP template would be created to support Member States in their policy planning, communication and reporting, requiring annual progress reporting. The pesticide targets of the F2F Strategy would be mandatory at the EU level, but Member States would decide on their own contributions to the achievement of the targets. Member States would be required to collect pesticide use data from professional users and report to the Commission on the progress towards the targets.

The medium ambitious elements can be expected to create stronger human health and environmental benefits than the least ambitious ones. In particular, the action on more hazardous pesticides will impact the risk of human exposure and negative environmental consequences. This is achieved by introducing some costly elements, in particular the prescription system. However, in the balance between the elements and the legally binding targets there remains a risk of missing the target based on the experiences with the implementation of the current SUD in the Member States.

8.1.3 Most ambitious option

An option in which the most ambitious elements are combined would result in the most substantial change in comparison to the status quo. In addition to many elements of the medium ambitious option, this option would ban all pesticide use in sensitive areas, use data on IPM implementation for enforcement through controls and define parameters for the spraying from drones in the future. The pesticide related targets of the F2F strategy would be legally binding at the EU level and to be achieved by each Member State.

The most ambitious measures would mean that a maximum of benefits for human health and environmental systems can be expected, compared to the previous options. However, the additional compliance costs for professional users and Member State authorities in comparison to the current SUD would also be the highest. Additional impacts on the yields of agricultural production, subsequent food prices and the competitiveness of the EU's food supply chain can be expected as well. Thus, the proportionality and efficiency of the option would be lower, even though a strong response to the problems is formulated. Furthermore, options such as the ban of pesticide use in sensitive areas may raise concerns over their conformance with the subsidiarity principle, depending on the final formulation and definition of such an element.

8.2 Option based on combination of elements

The policy options based on the level of ambition of the elements will likely not strike the right balance between cost and benefits. A combination of more and less ambitious elements is therefore explored in this section, starting with an option on strengthening of current provisions in the SUD, another option on aligning the SUD with the F2F ambitions, and finally the European Commission's preferred option which combine the two.

8.2.1 Option on strengthening current provisions

This policy option focuses predominantly on the strengthening of the current provisions of the SUD. As shown in the evaluation, some of the provisions are not working as intended and/or are subject to uneven implementation across the Member States. This includes the following three problems list below:

- The varying and limited operationalisation of the IPM principles;

- The varying and limited implementation of the SUD concerning testing of PAE;
- The varying and limited effectiveness of NAPs; and
- Potential shortcomings in training obligations

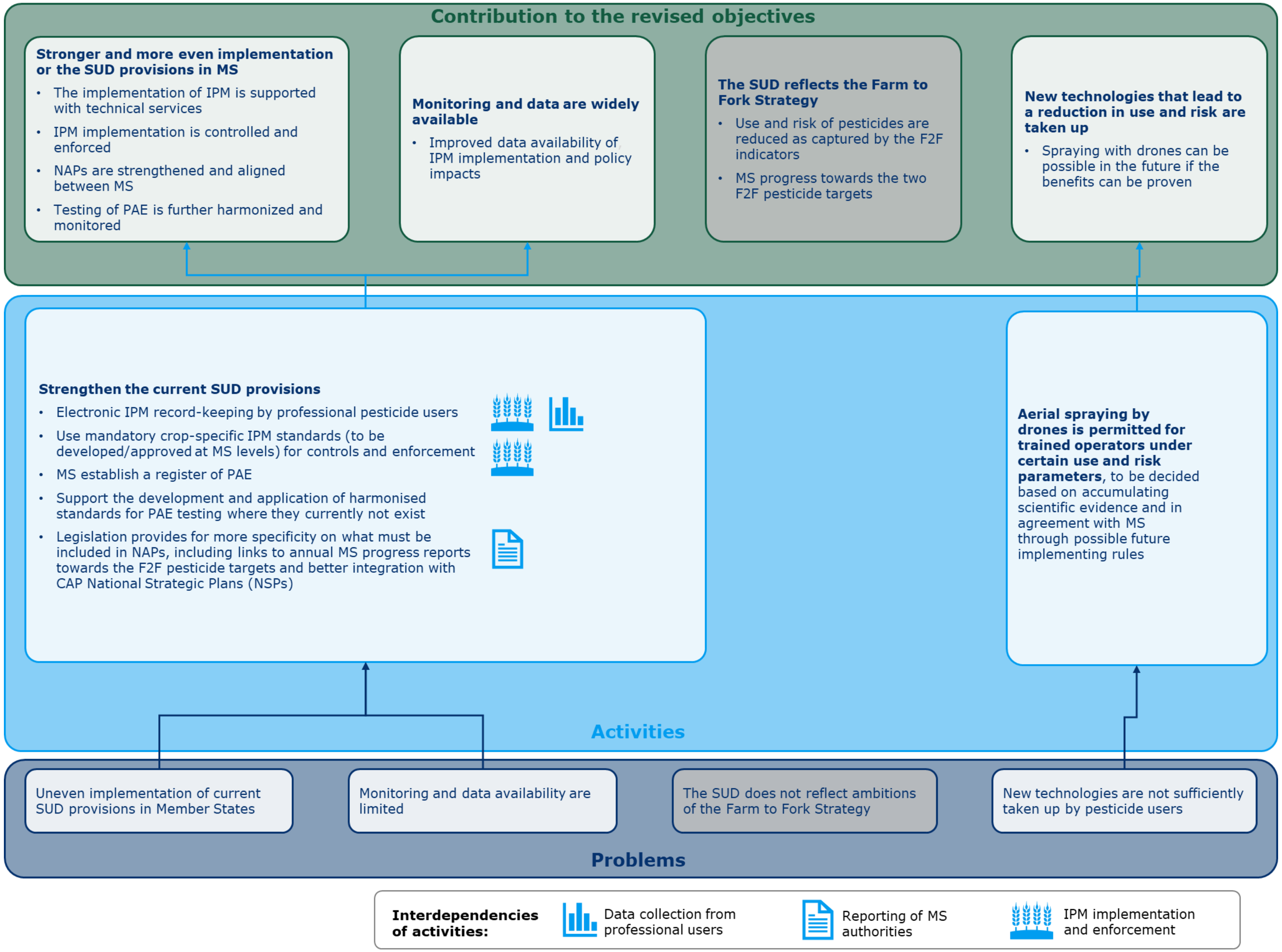
Also, this policy option incorporates elements addressing the uncertain situation regarding drones of the current SUD, which is also within the array of improving current provisions. For each of those problems a range of specific elements of options are assessed in detail in Appendix 2 of this report.

The policy option was compiled as a combination of all elements which are expected to perform best for addressing the specific problems, while also under the consideration that the creation of tailored crop-specific guidance could have strong potential of forming the basis for a range of other elements.

It should be noted that, while this policy option has the potential to address shortcomings of the current SUD and lead to a further decrease of use and risk of use of pesticides, it is uncertain if this policy option alone would suffice to reach the two pesticide related targets of the F2F strategy. This is because no new provisions are introduced that could be considered a "game changer" to the current situation and since no targets are set through this policy option which would motivate ambition.

The following Figure presents a policy option that seeks to account for these considerations.

Figure 8.1 Intervention logic of the policy option strengthening current provisions



8.2.1.1 *Key mechanisms*

This policy options combines the elements which have been assessed as likely to perform well by the contractor in the detailed assessment into a coherent package that addresses the shortcomings listed above.

The key elements of such a strengthened SUD would be as follows.

Problem: The varying and limited operationalisation of the IPM principles

Requiring from Member States to establish tailored IPM guidance (region/crop specific) representing crops covering at least 90% of UAA (A1.2.LE.b) could provide a solid basis for addressing this problem. It would be likely a challenging exercise for the Member States which would be facilitated by well-defined minimum criteria and guidelines from the European Commission for Member States to develop their guidance. Such a guidance would, besides the immediate benefit of providing direction to farmers within the complex field of IPM, allow policy option A1.1.ME. on establishing a mandatory common framework for electronic IPM record keeping by professional users to unfold its full potential by allowing this record keeping to be more tailored and meaningful than a high-level common framework at EU level. This tailored record keeping would likely also facilitate and improve the implementation of A1.1.MO.a, i.e. using mandatory crop-specific IPM standards as a basis for controls and enforcement. It should be noted that in order for record keeping (i.e. A1.1.ME.) to be meaningful beyond for statistics and policy making (both of which are beneficial objectives but with an impact only in the long-term) it needs to be paired with A1.1.MO.a. This would also to a larger extent justify the costs that would accrue for farmers for record keeping.

Further emphasising the current SUD compulsory requirement for MS to introduce incentives for the use of non-chemical pest control alternatives and methods as well as for any IPM measure that may lead to economic losses for farmers (i.e. A1.3.LE.a) would directly address one of the key drivers of this problem, which is the (perceived) risk by farmers from implementing IPM measures instead of directly relying on chemical pesticides. The tailored IMP guidance (A1.2.LE.b) could also play a role in this by linking payments for compensation to tailored criteria instead of high-level criteria which could likely be circumvented and/or exploited more easily. The record keeping (i.e. A1.1.ME.) would also be a request for this compensation mechanism to work.

Problem: The varying and limited implementation of the SUD concerning testing of PAE

The selected elements and thus mechanisms addressing this problem are the same as in the policy option in section 8.2.3 and are detailed there.

Problem: The varying and limited effectiveness of NAPs

While there is no clear definition of what a template is, policy option A3.1.ME.a (template provided on NAP structure and improved Commission guidance on NAP reporting, including reduction of use and risk for health and environment) would likely lead to improved quality and comparability of the NAPs, (compared to policy options A3.1.LE.a[244] and A3.1.LE.b[245]) which would balance the additional costs for Member States in preparing the NAPs.

However, as part of this policy option, each of the three aforementioned elements could potentially be included, since all of them address the problem (albeit potentially to a different degree as

[244] Legislation provides for more specificity as to what is included in NAP

[245] Commission takes stronger line in enforcement of existing requirement and in links to target

explained above) and since none of the other elements addressing the other problems are directly interlinked.

Problem: Potential shortcomings in training obligations

Only one potential element has been proposed under this problem, i.e. that all operators of PAE (i.e. pesticide users) must hold a certificate of training, instead of the current requirement that only the purchaser of the pesticides is trained (A4.1.LE.a). However, it has been found that, while the legal text of the current SUD could be interpreted in a way that only purchasers and not users are required to have training, it has been interpreted in line with A4.1.LE.a already by the Member States and thus no change is required.

Problem: Drones are not accounted for in the current SUD

As part of this policy option, the use of drones would be allowed by trained operators under certain use and risk parameters, to be decided based on accumulating scientific evidence and in agreement with MS through possible future implementing rules (i.e. D2.1.ME.a) would address the problem that drones are not accounted for in the current SUD. Potentially, those use and risk parameters could also be defined in the tailored IPM guidance (region/crop specific) representing crops covering at least 90% of UAA (A1.2.LE.b).

8.2.1.2 *Impacts*

The costs of the policy option can be summarised as follows:

- Professional users would face additional costs compared to the status quo from the time spent for data recording and electronic submission as well as potentially for fees from controls. Also, costs could accrue from additional inspections due to higher inspection standards. Potentially, they would also face costs for adapting practices according to guidelines but those would vary widely at rotation level per plot/field in addition to the crop level and with considerable differences across crops, regions, production types. While those costs could be somewhat high, as part of this policy option it would also be envisioned that the farmers are compensated to some extent by Member States (see also below for benefits).
- Member State authorities would face costs for collection and assessment of IPM data, for controls of IPM implementation (even though those could also be recovered from farmers in form of fees in which case the farmers would face those costs), for the revision and creation of crop-specific guidance as well as for the compensation of IPM practices. Also, costs would arise from revising the NAPs to reflect specifications of a template to be provided by the Commission.
- The European Institutions would in general face limited costs and mostly related to providing guidance and assessment of data.

No change in terms of overall costs from this policy option would occur compared to the likely costs assessed for the single elements (see Appendix 2).

The costs are contrasted by benefits for different groups, which can be summarised as follows:

- For society in general, benefits arise from reduced risk for human health and for the environment. Improvements on human health can be expected from reduced exposure to pesticides. However, the extent of this is likely lower than from the preferred policy option (see section 8.2.3), given that no additional provisions are introduced, and it is likely that not the same level of reduction of use and risk of use would be achieved as from the ambition from the two pesticide related F2F targets.
- Professional users can potentially reduce expenses for pesticides through wider implementation of IPM principles and thereby benefit from the revised Directive. However, these benefits are

uncertain, depend on the crop type and are likely to be observed only in the long term. Also, they could benefit from compensation for the implementation of certain IPM practices.

- Member State authorities would benefit from improved clarity on requirements towards their NAPs, reporting obligations and the authorisation of drones for spraying.

8.2.2 Aligning with F2F ambition and improved monitoring

This policy option is to a large extent similar to the preferred policy option lined out in section 8.2.3 and this thus not assessed here in detail.

The principal difference in this policy option is that very little concrete guidance is provided to the Member States on how to reach the two pesticide related targets since no changes are envisioned to strengthen the current provisions. This would lead to a situation in which Member States have even more flexibility in addressing the objectives of the SUD and consequently achieving the two-pesticide related F2F targets than is already the case since no concrete elements are provided of how Member States should achieve the reduction of use and risk of use of pesticides. While the flexibility (manifested in the form of a Directive as compared to a Regulation) has in general been considered positive by most stakeholders (see findings for EQ4 in the evaluation), the increase of ambition (introduced through the two-pesticide related F2F target) without providing guidance on how to reach them (i.e. at least partly in form of the strengthened provisions) would lead to an even more uneven implementation across Member States.

Also, given the expected positive outcomes for comparably low costs stemming from the strengthening of current provisions as well as the need for clarity concerning the legal situation of drones, this policy option it is not considered favourable as compared to the others, and specifically the preferred policy option lined out in section 8.2.3.

8.2.3 Aligning with F2F ambition, strengthening current provisions and improved monitoring – preferred option by the European Commission

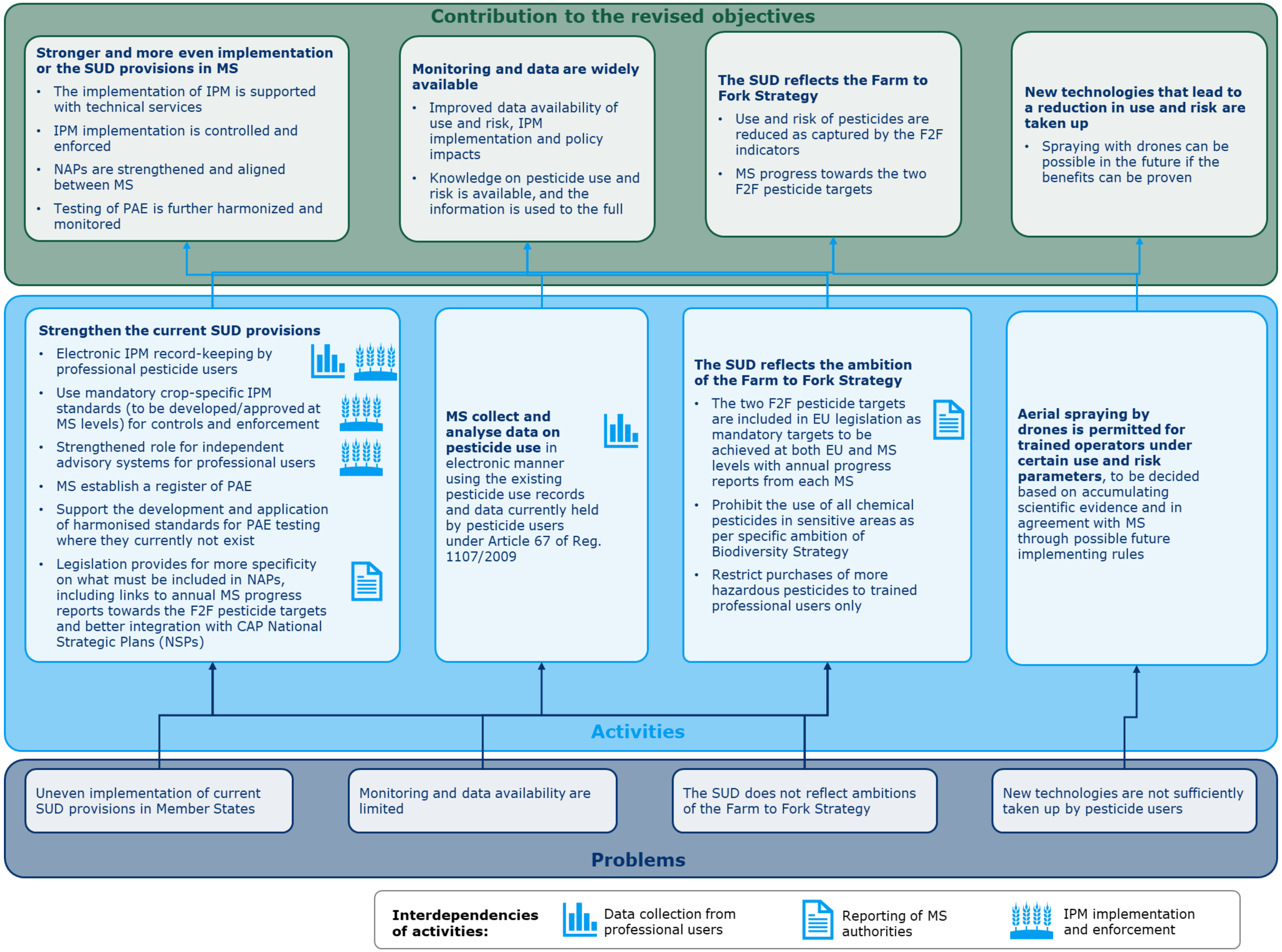
With the aim of maximising effectiveness while minimising the cost burden to stakeholders and policymakers, the following set of considerations has been taken into account:

- In order to achieve legally binding targets on the reduction of pesticide use and risk, for all chemical as well as for more hazardous pesticides, additional supporting measures are needed that lead to a risk and use reduction captured under the relevant indicator. Therefore, an element of legally binding targets would benefit strongly from being supported by measures that aim at reducing the use of more hazardous pesticides, or of all chemical pesticides.
- The reporting of Member States on the progress towards the F2F targets can be combined with reporting on progress on their NAPs and other related policy fields (CAP NSPs), which would reduce the burden to some extent.
- The necessary improvements of data collections on pesticide use and IPM decision making can be made combined in one electronic system to minimise administrative burden for pesticide users and costs for authorities.
- Record keeping on IPM decisions would have to be based on standards such as crop-specific IPM guidelines. These would have to be available at the appropriate level (relevant to the crop and production context) for record keeping and potential controls of IPM implementation.
- More generally, any additional efforts on increasing the enforcement of provisions in the SUD would have to be supported by monitoring and data availability on use and risk, because currently available data is too limited to assess the effects of measures, particularly at a higher spatial granularity than the country level.

- Similarly, the effective testing of PAE requires a register of such equipment at Member State level as well as shared standards for tests in order to create a harmonised framework across the EU.

The following Figure 8.2 presents a policy option that seeks to account for these considerations and has been identified as the preferred policy option by the Commission.

Figure 8.2 Intervention logic of the preferred option



8.2.3.1 *Key mechanisms*

The option combines elements to address the main problems identified. The evaluation of the current SUD has found an added value in the EU action undertaken in the Directive, but limited effects in practice and across Member States. Based on this finding, strengthening the implementation and harmonisation of the existing measures can improve the performance and effectiveness of the SUD.

The key elements of such a strengthened SUD would be:

- Requiring electronic records from professional users on the application of IPM principles. These would be based on a wide coverage of crop specific IPM guidance's and possibly mandatory advice for professional users from independent advisors. The guidelines in combination with the records of users can be used to control and enforce the implementation of IPM across the EU. This would also enable the development of more targeted measures or support in areas, times or crops that underperform on the respect of the IPM principles.
- Similarly, a register of pesticide application equipment (PAE) would enable more systematic and comprehensive controls of such equipment as well as providing more reliable data on testing frequencies and the status of PAE in use in the EU. The quality of testing would also be supported by harmonised standards developed by e.g. a standard setting body at the EU or international level. This would also reduce the burden for authorities to create testing catalogues and facilitate the trade and use of PAE in different Member States.
- The national planning of these two elements and the other ones that form the current SUD would be improved by clearer indication in legal form on the necessary elements of a NAP. This addresses the variety in NAPs that has been found to limit the possibility to follow up. With more specific requirements, reporting in a relatively standardised way will be possible to take place annually, with possibilities for strong synergies with the reporting foreseen in the proposal for CAP National Strategic Plans (NSPs)[246]. This will include the progress on the indicators for the two pesticide related targets of the F2F Strategy, meaning that several reporting obligations for Member States can be combined.

The key challenge in determining the success of the different measures was found to be a highly limited availability of data concerning the implementation of IPM and of pesticide use in e.g. different areas, times and crops. Data on IPM implementation is created through the above mechanism. Data on the use of pesticides is already existing at the user level under Article 67 of Regulation (EC) 1107/2209. Making it available for aggregated national statistics with possible breakdowns on parameters such as crop type or application time will help to better understand risks to human health and the environment, and improve the design of policies in the future.

The key political context that needs to be addressed by a revised SUD are the pesticides targets defined in the F2F Strategy. Adding them in legally binding form to the SUD would require additional action by Member States. The planning of such actions would be facilitated by the requirements towards NAPS and the results would also be reported jointly. The progress towards achieving the targets would have to be based on a change in the risk profile of the pesticides used, or on a reduction of use. Therefore, elements that contribute to these two components are included in the option. First, a ban of the use of chemical pesticides in sensitive areas would reduce the overall use, as the area for pesticides would decrease. Second, a training requirement for the purchase of more hazardous pesticides would cause a shift in the risk profile of pesticides used by non-

[246] European Commission, "COM(2018) 392 Final: Proposal for a Regulation of the European Parliament and of the Council Establishing Rules on Support for Strategic Plans to Be Drawn up by Member States under the Common Agricultural Policy (CAP Strategic Plans) and Financed by the E," *Official Journal of the European Union*, 2018, https://eur-lex.europa.eu/resource.html?uri=cellar:aa85fa9a-65a0-11e8-ab9c-01aa75ed71a1.0003.02/DOC_1&format=PDF.

professional users. Both these actions combined contribute to the progress towards the two pesticide targets.

Finally, defining parameters for the use of drones for pesticide spraying will give a harmonised framework to this type of technology in the future, when more are clearer evidence on the effects on risk reduction is available.

8.2.3.2 *Impacts*

The impacts of the option are mainly shaped by the impacts of the various elements it combines. The assessment of the elements is provided in Appendix 1, with detailed cost-benefit assessments where possible and relevant.

The costs of the policy option can be summarised as follows:

- Professional users would face additional costs compared to the status quo from the time spent for data recording and electronic submission. These costs can be expected to be substantial overall at the EU level, but shared by the large number of professional users. Additionally, a ban of chemical pesticides in sensitive areas could result in a reduction of yields from those areas. Depending on the final definition of sensitive areas a substantial share of agricultural areas could be impacted by such a provision, and thus result in high direct costs for farmers. If professional users are obliged to use independent advisory services promoting IPM, this would have a direct additional cost, but could be offset by the savings of using less pesticides.
- Member State authorities would mainly be impacted by planning and reporting requirements on the elements. The main costs would arise from revising the NAPs to reflect the specifications, setting up electronic data collection systems, analysing the data recorded by pesticide users, and prepare annual progress reports to the Commission. The additional costs depend on the current level of implementation and can overall be expected to be at medium level.
- Non-professional users would face costs for a training in order to remain able to purchase more hazardous pesticides. The overall extent of these costs is unknown as statistics on the number of non-professional pesticide users do not exist and their user profiles differ substantially.
- Pesticide producers would likely see a change in demand for their products because of the ban in sensitive areas and the requirements for non-professional users. The extent is however impossible to predict based on the current specifications of the elements.
- The EU society would likely see increasing food prices because of the higher production costs and reduced yields of agricultural production.

In comparison to the costs of the elements in isolation, their combination in this option would reduce the costs for data submission by professional users, and for reporting by Member State authorities. Some time would still be required but this can be assumed to be substantially lower than both elements added up.

The costs are contrasted by benefits for different groups, which can be summarised as follows:

- For society in general, benefits arise from reduced risk for human health and for the environment. Improvements on human health can be expected from reduced exposure to pesticides. The main contribution to this benefit is achieved from the ban of chemical pesticides in sensitive areas, which includes green urban areas close to a large number of people and to vulnerable groups such as children. In addition, a training requirement for non-professional users (and a related ban for non-trained users) for more hazardous pesticides and harmonised testing of PAE can also be expected to reduce the exposure of pesticide users and bystanders. The impact assessment also found that environmental benefits from legally binding pesticide targets, supported by mechanisms such as the ban of chemical pesticides in sensitive areas, would increase soil and water quality, particularly in such areas that have high environmental value as habitats or for ecosystem services. The benefits to biodiversity and pollination services are less clear as a number of pressures affect these, which would need to be addressed in addition to pesticide risk and use. Quantifying these benefits or monetising them is not possible.

- Professional users can potentially reduce expenses for pesticides through wider implementation of IPM principles and thereby benefit from the revised Directive. However, these benefits are uncertain, depend on the crop type and are likely to be observed only in the long term.
- Member State authorities would benefit from improved clarity on requirements towards their NAPs, reporting obligations and the authorisation of drones for spraying.
- Other industries and parts of the food production value chain would likely benefit from the efforts to achieve the F2F pesticide targets. This applies to agricultural machinery producers and advisors but also to beekeepers and drinking water suppliers (less costs from pesticide pollution).

Overall, the assessment finds that the main costs would be borne by professional pesticide users, similar to the conclusion in the evaluation of the current SUD. The expected gain would be a reduced use (cost) of pesticides. However, the combination of record keeping elements (pesticide use and IPM) ensures that costs for pesticide users are kept as low as possible. The impacts on production costs and higher risks of loss of yields remain. The benefits of the option relate to the reduction of risk for human health and protection and restoration of natural compartments and ecosystem services. The evaluation and context of this impact assessment have shown that increased action is needed on these issues. However, because the benefits are impossible to monetise, weighing costs and benefits of this option is not possible.

8.2.4 *Summary of costs and benefits of the options (based on detailed assessment of elements in Appendix 1)*

	Professional pesticide users		National Authorities		Other stakeholders	
	Cost assessment	Benefit assessment	Cost assessment	Benefit assessment	Cost assessment	Benefit assessment
Strengthen current SUD provisions						
Electronic IPM record keeping by professional pesticide users	EUR 278 million investment cost (27 Euro per farmer) EUR 742 million per year (74 Euro per farmer and year on average)	Potential reduction of costs for pesticides (up to 25%), health benefits	800.000 Euro annually (if linked to FSDN)	N/A	Reduced sales of pesticides	Potential market for decision making software and application Increased sales of biocontrol and alternative methods
Development of crop specific guidance	Potential costs related to IPM measures	Potential reduction of costs for pesticides (up to 25%), health benefits	Costs for revising and developing guidance (depends on baseline in each country)	N/A	Reduced sales of pesticides	Consultancies and research institutes would receive funding and resources for development and revision of guidelines
Use mandatory crop-specific IPM standards as a basis for controls and enforcement	Potential costs related to IPM measures	Potential reduction of costs for pesticides (up to 25%), health benefits	Euro 1.3 million per year	N/A	Reduced sales of chemical pesticides	Increased sales of biocontrol and alternative methods

	Professional pesticide users		National Authorities		Other stakeholders	
	Cost assessment	Benefit assessment	Cost assessment	Benefit assessment	Cost assessment	Benefit assessment
Strengthened role for independent advisory system	Obligatory strategic advice Large farms 540 Euro per year, Small farms 180 Euro per year	Potential reduction of costs for pesticides (up to 25%), health benefits	National authorities 530,000 Euro annually for control and administration Costs to establish independent advisory system	N/A	Reduced sales of chemical pesticides Costs to establish independent advice	Increased sales of biocontrol and alternative methods Strengthened sector for advisory services
Promoting harmonised standards for PAE testing	No additional cost for inspections, potential additional costs for mandatory repairs	Health benefits, less spillage of pesticides	N/A	N/A	Potential costs to adapt to harmonised standards	Better harmonisation of testing standards contributing to functioning internal market
More specificity on NAPs and links to CAP	N/A	N/A	Minor costs	Better policy implementation and follow up	N/A	N/A
SUD reflects ambition of F2F strategy						
Mandatory targets at EU and MS level	Potential costs related to IPM measures	Potential reduction of costs for pesticides (up to 25%), health benefits	Not possible to estimate	N/A	Reduced sales of chemical pesticides	Increased sales of biocontrol and alternative methods Reduced costs for water providers Health and environmental benefits for society as a whole

	Professional pesticide users		National Authorities		Other stakeholders	
	Cost assessment	Benefit assessment	Cost assessment	Benefit assessment	Cost assessment	Benefit assessment
Prohibit the use of all chemical pesticides in sensitive areas	Costs for farmers in protected areas to transform to organic farming Potential lower yields	Health benefits Higher prices on produce	Potential increased costs for alternative methods to pest control in sensitive areas	N/A	Reduced sales of chemical pesticides	Reduced costs for water providers Health and environmental benefits for society as a whole
Restrict purchases of more hazardous pesticides to trained professional users	N/A	N/A	Cost for control/enforcement of rules	N/A	Reduced sales of chemical pesticides Costs for non-professional users to become trained	Potential economic benefit to training providers Reduced costs for water providers Health and environmental benefits for society as a whole
Improved monitoring						
MS to establish a register of PAE	Almost no cost	N/A	Almost no cost (however, depending on mechanism chosen for register there could be some costs)	N/A	N/A	Environmental and social benefits, however only indirectly since this policy option is only an enabler for better testing

	Professional pesticide users		National Authorities		Other stakeholders	
	Cost assessment	Benefit assessment	Cost assessment	Benefit assessment	Cost assessment	Benefit assessment
Electronic data collection of pesticide use data held by professional users	Likely costs to report electronically. Potentially similar to assessment on IPM reporting (see above)	N/A	Costs to develop and implement electronic data collection	Better evidence base for policy actions	N/A	Environmental and social benefits, however only indirectly since this policy option is mainly related to improving knowledgebase
Adapting to new technologies						
Allow spraying with drones is allowed by trained operators	No additional costs	Health benefits through less exposure and safer treatment in hard to reach areas Potentially less labour costs Potential reduction in pesticide use, due to spot treatments	Minor costs for control	N/A	N/A	Economic benefit to producers of drones and potential service providers

9. Monitoring and evaluation arrangements

This chapter outlines the relevant arrangements to monitor progress and outputs of the policy elements. As the Commission has identified the option discussed in Section 8.2.3 as the preferred one, the monitoring and evaluation arrangements for this option will be focused on.

As has been found in the evaluation, monitoring the progress on the overall objectives of reduced risks of environmental and human health impacts has proven difficult in the past. The main reasons for this are the challenges to attribute health and environmental impacts to the use of pesticides due to the time lag between use and impact, the interaction of multiple substances and their accumulation in organisms. The challenge of attributing impacts to pesticide use will remain in the future, making it difficult to establish indicators that reflect the risk for humans and the environment. However, the collection of pesticide use data from professional users will enable the better assessment of the risks of pesticide use to different ecosystems or groups of society.

The Commission has already defined indicators to measure the achievement of the two F2F pesticide targets[247]. These will form the basis of the central monitoring of evaluation of the progress towards these targets at the EU and at Member State level.

Additionally, relevant indicators for the operational objectives under each specific objective are proposed and presented in Table 9.1.

Table 9.1 Relevant indicators for monitoring of operational objectives

Operational objectives	Relevant output indicators
Stronger and more even implementation or the SUD provisions in the Member States	
The implementation of IPM is supported with technical services	• Number of farmers using independent advice services • Share of farmers using independent advice services
IPM implementation is controlled and enforced	• Share of UAA of the EU for which crop specific IPM guidelines are available • Share of professional users submitting electronic records on IPM implementation • Share of professional users controlled for IPM implementation per year
NAPs are strengthened and aligned between MS	• Number of NAPs in compliance with legal specifications
Testing of PAE is further harmonized and monitored	• Number of Member States with PAE registers • Harmonised standards for PAE testing are developed
Monitoring and data are widely available	
Improved data availability of use and risk, IPM implementation and policy impacts	• Share of professional users submitting electronic records on IPM implementation • Share of professional users submitting pesticide use data electronically

[247] See: https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/farm-fork-targets-progress_en

Operational objectives	Relevant output indicators
Knowledge on pesticide use and risk is available, and the information is used to the full	• Use and risk data is available in all Member States
The SUD reflects the F2F Strategy	
Use and risk of pesticides are reduced as captured by the F2F indicators	• The two F2F indicators defined by the Commission are achieved at the EU level
MS progress towards the two F2F pesticide targets	• The two F2F indicators defined by the Commission are achieved in each Member State
New technologies that lead to a reduction in use and risk are taken up	
Spraying with drones can be possible in the future if the benefits can be proven	• Parameters for aerial spraying by drones are defined

Appendix 1: ASSESSMENT OF IMPACTS OF THE FARM TO FORK PESTICIDE TARGETS

10. Assessment of social, economic and environmental impacts of the Farm to Fork pesticide targets

10.1 Environmental impacts

Pesticides are strictly regulated to ensure their use does not harm human and animal health and the environment at the EU level. The plant protection products authorisation procedure involves risk assessment of active substances, performed by national risk assessment agencies and reviewed by the European Food Safety Authority (EFSA), who present recommendations to the European Commission risk managers. It is noted that the authorisation process, unlike similar chemicals regimes such as the REACH Regulation (EC) No 1907/2006, does not yet include an evaluation of the socioeconomics of plant protection product use to truly understand its sustainability.

When impacts to the environment from pesticide use occur, it is generally when the product use instructions have not been followed appropriately, or weather events such as heavy rainfall following application occur. There may also be environmental issues that only come to light some years post-registration.

In France, selected farms are being studied for the consequences of pesticide reductions in use that could provide an evidence base for an environmental impact assessment (IA). The National Action Plan ECOPHYTO project closely reflects the reduction in use of pesticide target in the F2F Strategy by corresponding to 37, 47 and 60% reductions in herbicide, fungicide and insecticide use across the DEPHY farm network[248]. The study has reported productivity and profitability results but is yet to report environmental outcomes. However, some early findings indicate that it may be easier to target specifically a decrease in herbicide, or fungicide or insecticide use, than to distribute the lowering throughout all pesticide categories. This study may be used to reflect upon environmental impacts of the pesticide targets in the F2F Strategy as results emerge. Initial findings also indicate that a pesticide reduction target exclusively focused on the agricultural/farmer component, without consideration for the restructuring of the sectors upstream and downstream of producers, cannot remove the social and technical barriers at work today (See Section 10.2).

A holistic environmental perspective of sustainable pesticide use and food or biofuel production may be taken by addressing biodiversity and ecosystem services (or natural capital). An ecosystem services approach is advocated by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) as one factor for increasing the effectiveness, efficiency and equity of the CAP[249]. It also underpins the EU Biodiversity Strategy, and is used by the EFSA in its Specific Protection Goals in PPP authorisation[250]. The integration of an ecosystem services approach to pesticide risk assessment was also recently promoted in a CEFIC and SETAC workshop[251,252,253]. Importantly, an ecosystem services approach can illustrate trade-offs between services in-field (cropped area) and off-field (surrounding environment), and incorporate socio-economic

[248] Lechenet M, Dessaint F, Py G, Makowski D, Munier-Jolain N. Reducing pesticide use while preserving crop productivity and profitability on arable farms. Nature Plants. 2017 Mar 1;3(3):1-6.

[249] https://ipbes.net/events/launch-ipbes-ipcc-co-sponsored-workshop-report-biodiversity-and-climate-change

[250] EFSA Scientific Committee. Guidance to develop specific protection goals options for environmental risk assessment at EFSA, in relation to biodiversity and ecosystem services. EFSA Journal. 2016 Jun;14(6):e04499.

[251] https://cefic-lri.org/projects/eco-45-chemicals-assessment-of-risks-to-ecosystem-services-cares-ii/

[252] Maltby L, Brown AR, Faber JH, Galic N, Van den Brink PJ, Warwick O, Marshall S (2021) Assessing chemical risk within an ecosystem services framework: Implementation and added value Science of the Total Environment

[253] Van den Brink PJ, Alix A; Thorbek P; Baveco H; Agatz A; Faber JH; Brown AR; Marshall S; Maltby L (2021) The use of ecological models to assess the effects of a plant protection product on ecosystem services provided by an orchard. Science of the Total Environment 798: 149329

information, to inform policy decisions. The primary in-field ecosystem service is generally optimised for food, feed, fibre, energy and other products for human consumption and processing with benefits for farm revenue.

In this IA, the selection of environmental indicators has been informed by the 2020 EU Ecosystems Assessment report (see Mapping and Assessment of Ecosystems and their Services - MAES[254]), which is based on European wide, harmonised datasets. Ecosystem functions and services are interconnected and underpinned by biodiversity. In the context of MAES, agroecosystems are defined as communities of plants and animals interacting with their physical and chemical environments that have been modified by people to deliver provisioning ecosystem services. Baseline conditions and the potential impacts on these indicators are explored across five types of ecosystem service categories, as follows:

- Biodiversity and landscapes;
- Maintenance of soil quality;
- Water quality regulation and aquatic biodiversity;
- Crop pollination; and
- Biological pest control.

10.1.1 Drivers for environmental change

Agricultural policy has been influential in shaping European landscapes and the nature they contain. The pressures and threats for terrestrial species, habitats and ecosystems most frequently reported by Member States are associated with agriculture[255]. Europe is experiencing a decline in biodiversity primarily due to the loss, fragmentation and degradation of natural and semi-natural ecosystems and agricultural intensification, and the use of pesticides is only a part of the picture.

One of the main mechanisms to address environmental pressures from agriculture has been the mainstreaming of environment and climate objectives into the CAP. Overall, the integration of environmental objectives into the CAP does appear up to 2020 to have resulted in some reductions in environmental pressures, such as nutrient emissions, but this is tempered by the continuing decline in biodiversity. The European Farm-to-Fork and Biodiversity strategies follow from the EU Green Deal and the expectation was that they would be implemented through the CAP. However, the draft policy framework for CAP reform in 2018 preceded these strategies and, as such, falls short of the Green Deal objectives and targets[256]. In fact, both the European Parliament and the Council of the EU voted (in October 2020) against the explicit inclusion of the strategies' targets in the CAP for the 2020-2027 period.

This section will focus on discussing what could be the environmental impact of making pesticides targets in the F2F Strategy legally binding, i.e. what additional benefit would they bring to the environment?

The main drivers of environmental change in relation to pesticide use are summarised in the table below. Environmental compartments and biodiversity are interconnected and, as such, many drivers relate to more than one environmental indicator and can be aggregated. For example, the issue of mixture toxicity of multiple pesticides (and pesticides acting with other chemicals in the

[254] Maes, J.,et.al., Fernandez Ugalde, O., Santos-Martín, F., Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN, Publications Office of the European Union, Ispra, 2020, ISBN 978-92-76-17833- 0, doi:10.2760/757183, JRC120383.

[255] https://www.eea.europa.eu/soer/2015/europe/agriculture

[256] Guyomard H, Bureau JC, Chatellier V, Détang-Dessendre C, Dupraz P, Jacquet F, Reboud X, Réquillart V, Soler LG, Tysebaert M. 2021. European Parliament - The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU's natural resources.

environment) is uncertain, applicable to each environmental compartment, and currently not sufficiently accounted for in pesticide regulation. Drivers relating to specific environmental indicators are presented in each indicator-specific section.

Table 10.1 Summary of drivers for environmental change

	Drivers
Environmental variability and natural resources	• Crop type (permanent or annual; self-fertilising), crop cover, intercropping, mulching, cultivar mixtures, fallow land • Soil-related drivers, such as soil type • Water-related drivers, such as protection of drinking water resources • Biodiversity-related drivers, such as buffer zones or field margins • Pollinator-related drivers, such as disease • Land use change, habitat fragmentation and connectivity • Invasive alien species, especially in island ecosystems • Fluctuations in pest pressure • Timing and frequency of applications • Chemical mixtures leading to synergistic or additive toxicity • Existing levels of contamination, including residues • Drought and extreme temperatures • Rainfall and floods • Natural hazards and wildfires • Resource scarcity and competition for access
Socio-Economic influence	• Urban development • Changes in crop distribution/crop type • Changes in pesticide price and availability • Change in application methods • Agricultural subsidies • Evolution of the farming sector to face environmental challenges, policy changes and consumption models • Farm advisory and farmer training • Addressing investment needs for securing compliance with EU objectives and matching these with available funding sources • Making effective use of the existing knowledge base to innovate further towards land sustainability in the agricultural sector
Science and Technological influence	• IPM principles • Crop protection developments, e.g., new breeding technologies, nanopesticides • Less persistent (hazardous) PPP • Digitalisation (precision agriculture; connectivity; virtual services) • Technological development • Efficiency improvements • Availability of low-cost PPP alternatives • New scientific data on the safety of new or existing active substances
Policy influence	• Biodiversity policies, e.g. EU Biodiversity strategy • EU Pollinator Initiative • EU Soil Thematic Strategy • Water policies[257], e.g. WFD, Groundwater Directive • EU climate targets/carbon farming in the EU / International climate agreements • Farm incomes • Increased area of organic farming/Organic action plan • Convention on Biological Diversity (COP15) - net gain biodiversity targets • 'Greening' of the CAP • Better policy implementation • Ensuring governance structures that allow effective coordination • Legislative framework for sustainable food systems

[257] EC (2017) Commission Staff Working Document

10.1.2 Barriers to quantitative impact assessment

To ensure that impacts are addressed appropriately, it is essential that policymakers are able to quantify the level of pesticide exposure to the environment, and the resultant risk. However, pesticide statistics are too aggregated to effectively inform environmental risk assessment. A robust analysis of the impacts of pesticide application on ecosystems would require data on which specific active substances in pesticides are applied to which crops, as well as information on the types of ecosystems in which those crops are sited. Data on hazard, i.e. ecotoxicological properties, is specific to active substances. Thus, the only way to effectively combine hazard with exposure data in order to understand risk is to have data on the application rates for specific active substances in pesticides by crop, area and ecosystem type. In addition, cumulative and 'cocktail' risk assessment methods, would need to be applied to provide an understanding of how the mixtures of active substances, safeners and synergists interact to generate combined effects in pesticides.

Should pesticide use statistics become available at a sufficient level of detail, they could be useful for conducting retrospective risk assessments of the actual levels of risk expected from the overall use of pesticides in the EU, for human and animal health, and the environment. This would allow the estimation of trends based on risk to complement those on sales. As each active substance has a different toxicity and likelihood for exposure, trends based on their risk to human and animal health and the different non-target organism groups could be highly valuable for supporting EU policies on public health, consumer protection, animal health and environmental protection. Such assessments would complement the annual assessments of the risk to consumers from pesticide residues in foodstuffs monitored by the Member States.

10.1.3 Existing mechanisms for managing hazardous pesticides in the Baseline Scenario

The baseline assessment represents 'business as usual' for the use of pesticides in agriculture to 2030, including key environmental influences in the SUD such as integrated pest/weed management, and acknowledges new strategies and initiatives, such as the EU Biodiversity Strategy and the Pollinator Initiative.

Most of this IA focusses on intensively and conventionally managed agricultural landscapes, primarily annual crops. This presents and imbalance in the IA as there are many types of crops cultivated in different ways, which may be less impactful on the environment. It has been shown, for example, that permanent crops provide many ecosystem services benefits, such as recreational spaces for local people and strong regional traditions and identity (e.g. vineyards, cider making, citrus and olive groves)[258].

It is not yet clear in policy how the F2F targets of the 50% reduction in use and risk of chemical pesticides and the 50% reduction in the most hazardous pesticides would be implemented, however, existing measures are in place. Active substances are first approved for up to a maximum period of 15 years (depending on the type of substance). Approval may be renewed for a period not exceeding 15 years upon application under the systematic review of active substances known as the AIR-programme. When a pesticide is reviewed national authorities need to carry out a comparative assessment to establish whether more favourable alternatives to using the pesticide

[258] Deacon, S., Norman, S., Nicolette, J., Reub, G., Greene, G., Osborn, R. and Andrews, P., 2015. Integrating ecosystem services into risk management decisions: Case study with Spanish citrus and the insecticide chlorpyrifos. Science of the Total Environment, 505, pp.732-739.

Van den Brink PJ, Alix A; Thorbek P; Baveco H; Agatz A; Faber JH; Brown AR; Marshall S; Maltby L (2021) The use of ecological models to assess the effects of a plant protection product on ecosystem services provided by an orchard. Science of the Total Environment 798: 149329 exist, including non-chemical methods, these are known as candidates for substitution (CfS). The aim is to encourage more sustainable crop protection.

The current CfS list comprises a mix of active ingredients, mainly identified for environmental hazard (e.g. persistence and bioaccumulation properties) or human health effects. It is unclear how the 50% reduction in the most hazardous PPP target in the F2F Strategy would be achieved, if not through the renewal for approval mechanism?

Using currently available information on CfS downloaded from the European Commission Pesticides Database[259], one-third of active ingredients were not approved for use between 2017 and 2021 (35 of 103 active ingredients). There are 68 active ingredients currently approved for use on the CfS list with 50 of these Candidates identified as being of concern for "two PBT criteria". Member States have identified these as being of potential environmental concern for persistence, bioaccumulation or (eco)toxicity (PBT). Four of these fifty active ingredients are copper based and sold as organic pesticides (fungicides). It may be assumed in the baseline scenario that some of these active ingredients will not be re-approved in the years up to 2030.

There are 20 CfS identified on human health grounds (or both environmental and human health bases). A restriction on the use of PPP on human health grounds is unlikely to make a substantial difference to water or soil quality or biodiversity, although may influence groundwater quality and drinking water resources.

It is noted that emergency authorisations at Member State level will continue under both baseline and IA scenarios.

In addition, it is important to note that pesticide withdrawals may not bring instant environmental risk reduction. Some pesticides have the potential to accumulate in soils and in soft sediments in edge-of-field ponds, ditches and streams, where they are often more concentrated than in the water column[260]. The combination of ongoing exposure with accumulated pesticides (including withdrawn pesticides) may present a situation where ecotoxicity is greater in soils and sediments than in the water column[261]. Pesticide levels measured in aquatic systems, such as under Water Framework Directive monitoring programmes, may be underestimating the risk of ecological effects on freshwater biodiversity.

10.1.4 Biodiversity and landscapes

Biodiversity and nature sustain life on Earth, delivering numerous essential ecosystem services. They are a vital element of our cultural heritage and treasured for their recreational, spiritual and aesthetic values. As a result, biodiversity loss has fundamental consequences for our society, economy and for human health and well-being. Biodiversity underpins our landscapes and the resilience of traditionally cultivated agricultural land often depends on the diversity of species and habitats adjacent to cropped areas for recolonisation and recovery.

The European Commission states that forests and agroecosystems (cropland and grassland) dominate the 4.4 million km^2 of EU land area (EU27 and UK). Similarly, the European Ecosystem

[259] Candidates for Substitution list downloaded on 19 August 2021 - https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/active-substances/?event=search.as

[260] EFSA Panel on Plant Protection Products and their Residues. Scientific Opinion on the effect assessment for pesticides on sediment organisms in edge-of-field surface water. EFSA Journal. 2015 Jul;13(7):4176.

[261] Rasmussen JJ, Wiberg-Larsen P, Baattrup-Pedersen A, Bruus M, Strandberg B, Soerensen PB, Strandberg MT. Identifying potential gaps in pesticide risk assessment: Terrestrial life stages of freshwater insects. Journal of applied ecology. 2018 May;55(3):1510-5.

Assessment[262] (European Union, 2021) reported that agroecosystems cover almost half of the EU land area (36.4% cropland and 11.4% grassland). One of the greatest threats to biodiversity in agricultural ecosystems is land use change and the greatest land use changes are caused by urban expansion, at a rate of 3.4% every ten years. This expansion mainly consumes cropland, which decreases at a rate of - 0.3% every ten years. Grassland, heathland and shrub and wetlands have also continued to decline. Such dominance of European land usage, agricultural and forestry land present substantial opportunities for ecosystem restoration and climate mitigation through increased sustainable agricultural and forestry practices, including crop and forest species diversification and agroecology (IPBES, 2021).

Due to the prolonged interaction between natural and human systems, it is necessary to stress the perspective under which condition of agroecosystems is addressed. In MAES, for example, agroecosystems, in fact, do not have a corresponding "natural state", or degree of intactness that can be set as reference. Semi-natural features (e.g. field margins, hedges, grass strips, lines of trees, ponds, terraces, patches of uncultivated land) are considered an important part of agroecosystems, as from a pragmatic definition they are managed within the same context and affected by agricultural activities, and from an ecological perspective they are nesting and breeding sites, food sources, migratory corridors to fauna, supporting ecosystem services such as pollination, pest control and other regulating and cultural ecosystems services. Moreover, agrobiodiversity and in particular genetic resources for food and agriculture (e.g., wild crop relatives, plant varieties) represent an insurance for the future, guaranteeing the capacity to respond to crises (climatic, economic, etc.) contributing thus to food security[263]

10.1.4.1 *Policy drivers for biodiversity and landscapes*

The main policy driver is the EU Biodiversity Strategy for 2030 which addresses the main causes of biodiversity loss with the renewed objectives of halting this loss and restoring damaged ecosystems. Intensive farming prioritises food (and biofuel) production to secure livelihoods and to feed (or generate energy) for the population. However, intensification of agriculture has had a range of negative consequences for the health and quality of natural ecosystems. Partly, this arises from the use of inputs such as pesticides and chemical fertilisers, and partly it is a function of the prevalence of 'monocultural landscapes' in which there is little opportunity for nature. In turn, the loss of biodiversity leads to a need to intensify agriculture further[264]. So far, the CAP scheme has incentivised larger farms and the intensification of agriculture[121]There may be opportunities in the CAP reform to incentivise ecological restoration and biodiversity enhancement at farms of all sizes.

The negative impacts of agricultural intensification on crop pollination, bird communities, flora and soil biodiversity are emphasised in the EU Biodiversity Strategy. Among the provisions of the EU Biodiversity Strategy for 2030 include the target of 30% of land protected, and the provisions of no deterioration of all protected habitats and species. These are likely to require the development of ambitious and specific measures in the future CAP, with some agricultural areas subject to particular constraints.

Under the F2F Strategy, the Commission will take action to boost the development of EU organic farming area, with the aim to achieve 25% of total farmland under organic farming by 2030.

[262] European Commission. 2021. Environment A. Evaluation of the impact of the CAP on Habitats, Landscapes, Biodiversity. Final Report. 2019 Nov.

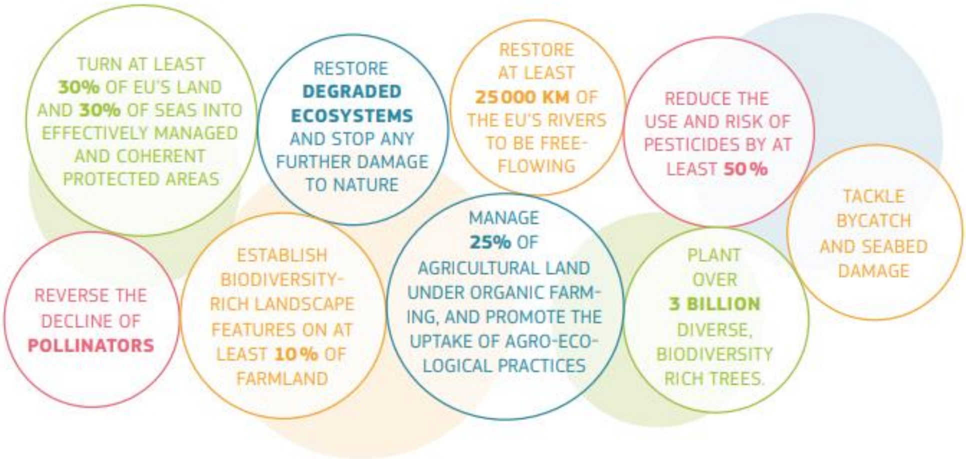
[263] Maes, J., et.al. 2020. Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN, Publications Office of the European Union, Ispra , ISBN 978-92-76-17833- 0, doi:10.2760/757183, JRC120383.

[264] Benton T, Bieg C, Harwatt H, Wellesley L, Pudasaini R. 2021. Food System Impacts on Biodiversity Loss Three Levers for Food System Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House. 2021:2021-02.

Additionally, under the EU Biodiversity Strategy to 2030, the actions on pesticides and organic farming are consistent between the two strategies, although the Biodiversity Strategy goes further to include restoration of degraded ecosystems, address pollinator decline and establish biodiversity-rich landscape features (undefined) on 10% of farmland (see Figure 10.1 below).

It is assumed in this IA that the additional actions in the EU Biodiversity Strategy will be enacted through the CAP, although this is uncertain. It is not yet known how the CAP will account for the targets in these strategies or implement plans.

Figure 10.1 Targets set in the EU Biodiversity Strategy to 2030 (from the European Union (2020) Factsheet on the EU Biodiversity Strategy)



Source: EU Biodiversity Strategy to 2030

In addition, the EU Ecosystems Assessment states that almost 600 km^2 of agroecosystems are lost each year due to soil sealing (urban expansion). Loss of habitat is seen as a primary threat to biodiversity in agricultural ecosystems. The report concludes that reversing negative trends in agroecosystems will depend on reducing key pressures that are still high, including land use and pesticide use. Improving the condition of agroecosystems and delivering the EU Biodiversity Strategy targets will be essential to safeguard agriculture-related biodiversity and important ecosystem services. The target to ensure 10% of farmland is highly biodiverse is a relatively small target and is unlikely to be sufficient to reverse declining biodiversity, but conversely, the land taken to restore "high-diversity landscape features" may also affect crop yields and revenues through a reduction in intensively managed agricultural land, which should be incorporated into financial incentivisation schemes (e.g. through the CAP) to ensure a win-win for nature and farm revenues.

The agricultural sector could potentially benefit from the Biodiversity Strategy by farmers receiving payments for the provision of ecosystem services. Typically, provisions such as the restoration of free-flowing rivers, freshwater ecosystems, soil organic matter and carbon storage could pave the way for the EU agricultural sector to benefit from a potential flow of "payments for ecosystem services" (PES). The provisions on green public procurement and those included in the "business case for biodiversity" could foster a regulatory environment that leads to a demand for such services that farmers are in a good position to provide[265]. Guidance and case studies on payment for

[265] Guyomard H, Bureau JC, Chatellier V, Détang-Dessendre C, Dupraz P, Jacquet F, Reboud X, Réquillart V, Soler LG, Tysebaert M. 2021. European Parliament - The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU's natural resources.

ecosystem services are available, for example, Smith et al, 2013[266]; Bohlen et al, 2009[267]; Lipper et al, 2009[268]; and, FAO's paying farmers for environmental services report[269]).

10.1.4.2 *Predicted changes in biodiversity and landscapes in the Baseline Scenario*

The European State of the Environment (2020) generally reports a "mixed picture" for the outlook on biodiversity, and a deterioration in common species (birds and butterflies) to 2030. It states that despite ambitious targets, Europe continues to lose biodiversity at an alarming rate and many agreed policy targets will not be achieved.

Assessments of species and habitats protected under the Habitats Directive show predominantly unfavourable conservation status at 60% for species and 77% for habitats. However, biodiversity loss is not confined to rare or threatened species. Long-term monitoring shows a continuing downward trend in populations of common birds and butterflies, with the most pronounced declines in farmland birds (32%) and grassland butterflies (39%). Europe's biodiversity and ecosystems face cumulative pressures from land use change, natural resource extraction, pollution, climate change and invasive alien species. These have a severe impact on ecosystem services — nature's benefits to people — as illustrated by the recent decline in insects, especially pollinators (see chapter 10.1.7 on pollinators). The EU Ecosystems Assessment surveyed biodiversity (birds, butterflies, protected habitats) with the results showing declining trends.

The European Environment Agency states that the broad framework of EU biodiversity policy remains highly relevant and is fit for purpose, but admits that targets to 2030 will not be met without more effective implementation and funding of existing measures in all European environmental policies, as well as greater policy coherence with respect to biodiversity in agricultural and other sectoral policies. The wider application of ecosystem-based and adaptive management, in combination with increased public awareness of society's dependency on biodiversity and nature are important steps forward.

Soil biodiversity

Soil ecosystem services are directly and indirectly related to the soil biodiversity and underpin many industries that use plant or animal products, not only for food and energy, but also clothes and pharmaceuticals[270]. Soil biodiversity maintains key ecosystem processes related to carbon and nutrient cycling, soil structure, and soil water balance. The State of the Environment report informs us that one hectare of agricultural soil contains about 3,000 kg of soil organisms, involving between 10,000 and 50,000 species and according to size and weight, earthworms dominate, whereas in terms of species richness, bacteria and fungi dominate (of which only 0.2 to 6 % are detected). Soil organisms not only provide stability in the face of stress and disturbance, but they also provide protection against soil-borne diseases[271]. Healthy soils also regulate and breakdown pesticides (biodegradation) in the environment.

[266] Smith S, Rowcroft P, Rogers H, Quick T, Eves C, White C, Everard M, Couldrick L, Reed M. Payments for ecosystem services: a best practice guide.

[267] Bohlen PJ, Lynch S, Shabman L, Clark M, Shukla S, Swain H. Paying for environmental services from agricultural lands: an example from the northern Everglades. Frontiers in Ecology and the Environment. 2009 Feb;7(1):46-55.

[268] Lipper L, Sakuyama T, Stringer R, Zilberman D, editors. Payment for environmental services in agricultural landscapes: Economic policies and poverty reduction in developing countries. Springer Science & Business Media; 2009 Mar 21.

[269] Food and Agriculture Organization (2007). The State of Food and Agriculture. Paying Farmers for Environmental Services.

[270] van der Putten WH, Ramirez KS, Poesen J, Winding A, Lemanceau P, Lisa L, Simek M, Moora M, Setala H, Zaitsev A, Economou-Eliopoulos M. Opportunities for soil sustainability in Europe. European Academies Science Advisory Council (EASAC); 2018.

[271] EEA, 2020. "ETC/ICM Report 1/2020: Pesticides in European Rivers, Lakes and Groundwaters - Data Assessment,",

Where pesticides have been shown through research or post-registration monitoring to present a risk to non-target soil organisms and are managed by existing legislation – such as the Candidates for Substitution list - then soil biodiversity over the next decade should improve from a pesticide fate and toxicity perspective. However, there remain physical impacts on soft-bodied soil fauna and microbial and fungal systems that are disrupted through mechanical land management, such as ploughing and tilling (see Section 10.1.5 on soil quality), which overall may not negate adverse management practices in intensively managed agricultural land. Within agricultural land, the intensity of the management system has been shown to affect most biological soil properties; however, in one study, the type of tillage, fertilisation and pesticide use were only related to the total microbial biomass and earthworm diversity, which were lower in sites in which fertiliser use was restricted, ploughed soils and sites with high inputs of pesticide[272].

Aquatic biodiversity

Aquatic biodiversity is mainly dealt with in section 10.1.6 and concluded diffuse pollution poses as the second main pressure (38%) on the aquatic environment with agriculture being the main contributor[273]. Whereas for groundwater, agriculture is the main cause for failure to achieve good chemical status due to diffuse pollution from pesticides (and nitrates). The European Environment Agency reported that Europe is not on track to meet policy objectives on water quality. It predicted a 'red light' warning in its outlook to 2030 based on continuing progress to restrict pesticide use, however, even reduced emissions will still contribute to further accumulation of persistent chemicals in the environment.

However, aquatic biodiversity is a vital resource. Uncropped areas around water bodies – riparian zones – serve as important habitats that integrate communities of plants and animals from aquatic and terrestrial environments. Many terrestrial species that directly improve food production also rely on riparian zones. Such species include insects that develop in streams, emerge as adults and feed a range of predators, including birds and spiders. In turn these predators, sustained by prey from non-cropped land, can control pests on farmed fields. Importantly, there is a feedback loop between terrestrial and aquatic ecosystems, as the degradation of aquatic ecosystems can negatively impact populations on land and vice versa. Riparian zones are also beneficial for reducing pesticide run-off and soil erosion into adjacent streams, which can affect water quality and aquatic communities[274]. The presence and health of riparian zones adjacent to cropped habitats rely on the abatement of over spraying, spray drift and greater use of IPM tools, such as precision technology, to mitigate impacts of pesticides on these habitats. Increased implementation of the SUD should improve protection of riparian habitats over the next decade and provide an improving picture to 2030.

Terrestrial biodiversity

The European Environment Agency reported the status of birds and butterflies from long-term monitoring data sets with good geographical and temporal coverage can provide trends that are linked to both policy and practice in terms of land use and management. Long-term trends (over 25 years) from monitoring schemes of common birds (in particular, farmland birds) and grassland butterflies show significant declines and no sign of recovery. Figure 10.2 below shows that, between 1990 and 2016, there was a decrease of 9% in the index of common birds in the 26 EU Member

[272] Virto I, Imaz MJ, Fernández-Ugalde O, Gartzia-Bengoetxea N, Enrique A, Bescansa P. Soil degradation and soil quality in Western Europe: current situation and future perspectives. Sustainability. 2015 Jan;7(1):313-65.

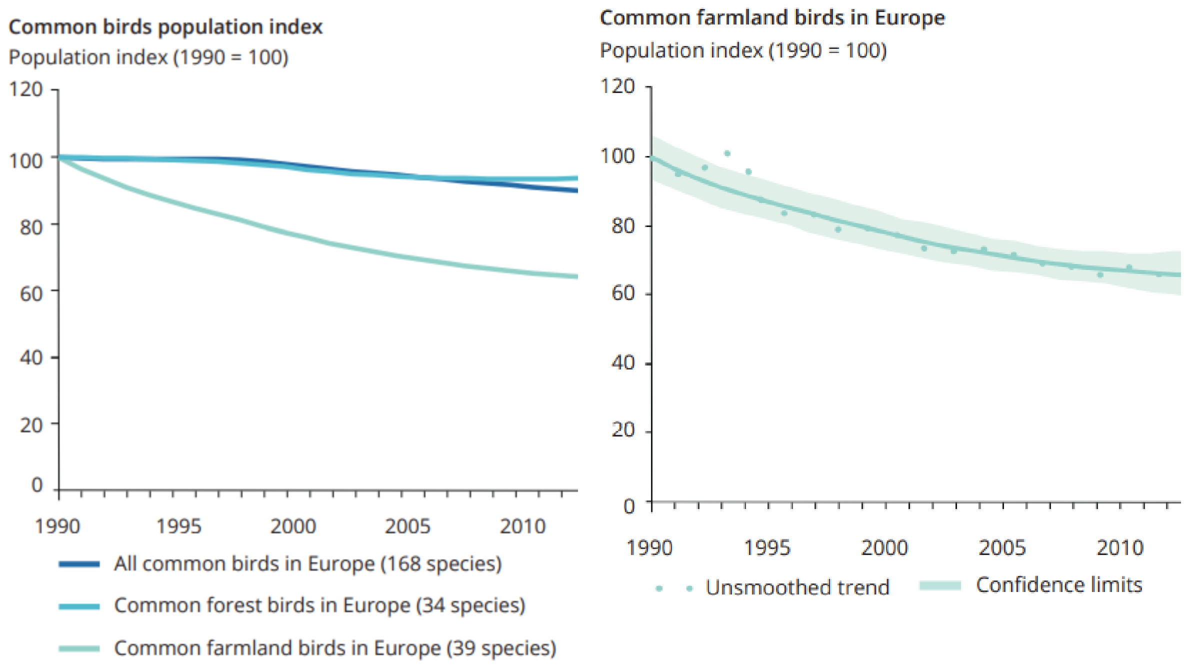
[273] (EEA, 2018)

[274] Benton, T., Bieg, C., Harwatt, H., Wellesley, L. and Pudasaini, R., 2021. Food System Impacts on Biodiversity Loss Three Levers for Food Sys-tem Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House, pp.2021-02.

States that have bird population monitoring schemes. This decrease is slightly greater (11%) when Norway and Switzerland are included. The decline of butterflies is even sharper with a 39% decrease in index value since 1990.

The State of the Environment report does not directly or solely attribute the declines to pesticide use, but instead to a range of factors including loss and fragmentation of natural habitats mainly caused by agricultural intensification (e.g. loss of hedgerows and tree lines), which lead to loss of nesting sites and food sources for birds. However, increased use of pesticides is highlighted for leading to reduced insect populations and seed production by plants, thereby reducing food for birds. The report states that apart from being an important source of food for birds and other animals, insects play a key role in ecosystem processes and provide various ecosystem services, such as pollination, soil nutrient cycling and providing pests, diseases and invasive alien species regulation. The vast majority of pollinator species are wild, including more than 20,000 species of bees, some species of flies, butterflies, moths, wasps, beetles, thrips, birds, bats and other vertebrates[275].

Figure 10.2 Common birds population index 1990-2016



Source: State of the Environment Report, 2020

The influence of pesticides in farmland bird decline is difficult to disentangle from land management factors[276]. For example, two similar studies of neonicotinoid exposure to farmland birds derived different conclusions. Hallmann et al (2014) used the Dutch long-term monitoring bird data and measurements of surface water quality to check to what extent water contamination by some neonicotinoid pesticides correlated with bird population trends. They found that higher concentrations of pesticide in surface waters were consistently associated with decreases in bird

[275] Potts SG, Imperatriz-Fonseca V, Ngo HT, Biesmeijer JC, Breeze TD, Dicks LV, Garibaldi LA, Hill R, Settele J, Vanbergen AJ. 2016. The assessment report on pollinators, pollination and food production: summary for policymakers. Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

[276] Burns, F., Eaton, M. A., Burfield, I. J., Klvaňová, A., Šilarová, E., Staneva, A., & Gregory, R. D. (2021). Abundance decline in the avifauna of the European Union reveals cross-continental similarities in biodiversity change. Ecology and Evolution, 11, 16647– 16660. https://doi.org/10.1002/ece3.8282

numbers. The authors concluded that the declines are predominantly linked to changes in the food chain, namely the depletion of insect food resources for birds. It could not be excluded, however, that declines in bird populations were also linked to trophic accumulation through consuming contaminated invertebrates or ingesting coated seeds[277]. Conversely, a study tested for spatio-temporal associations between neonicotinoid use and changes in the populations of 22 farmland bird species between 1994 and 2014, and to determine whether any associations were explained by dietary preferences. The researchers concluded that there was either no consistent effect of dietary exposure to neonicotinoids on farmland bird populations in England, or that any over-arching effect was not detectable using their study design[278]. These pesticides are currently the subject of restrictions, which should see a recovery in insect and bird numbers *if* the pesticides were causative.

The European Environment Agency states it is difficult to forecast how soon biodiversity, as illustrated by the abundance of bird and grassland butterfly populations, will recover, as their state is influenced by a complex combination of environmental factors and policy measures. Potential positive impacts of CAP reform and the measures anticipated under the multiannual financial framework 2014-2020 on common species associated with farmland may become apparent in the period 2020-2030, as long as these policies are implemented thoroughly and on a large scale throughout the EU[279]. On the other hand, other factors that could adversely impact the outlook beyond 2020 include the negative impact of climate change on biodiversity and ecosystems, particularly on those specialist species groups that are dependent on non-intensive agriculture and forest ecosystems. The increased competition for land could also intensify agricultural production in the EU, through land take via urbanisation as well as for producing renewable energy and biofuels.

Species-related indicators in the EU Ecosystems Assessment show no overall improvement, and in some cases further declines, particularly in agroecosystems. The analysis of trends in ecosystem services concluded that the current potential of ecosystems to deliver timber, protection against floods, crop pollination, and nature-based recreation is equal to or lower than the baseline values for 2010. At the same time, the demand for these services has significantly increased. A lowered potential in combination with a higher demand creates risks of further eroding the condition of ecosystems and their contribution to human well-being.

Terrestrial plants

In the case of weed control within a cropped habitat, the use of herbicides, organic, mechanical or other tools for weed management still aims to maintain a monoculture cropped habitat in intensively managed land and, as such, reduces opportunities for non-target plants (and other biodiversity) to colonise cropped habitat. However, ecological and socio-economic studies have shown that field margins and other adjacent habitats managed for conservation purposes can thrive for non-target

[277] Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, Stenmans W, Müller A, Sumser H, Hörren T, Goulson D. 2014. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE12 (10): e0185809.

[278] Lennon RJ, Isaac NJB, Shore RF, Peach WJ, Dunn JC, Pereira MG, et al. (2019) Using long-term datasets to assess the impacts of dietary exposure to neonicotinoids on farmland bird populations in England. PLoS ONE 14(10): e0223093.

[279] EEA, 2018. Common birds and butterflies, Briefing paper. Airs/2018/natural-capital/common-birds-and-butterflies

plants and other wildlife[280;281,282,283;284]. The policy drivers to increase biodiversity-rich landscapes and IPM strategies that conserve and enhance field margins will influence non-target plants as the building blocks for agricultural biodiversity to 2030.

Invasive alien species

The Ecosystems Assessment observed invasive alien species across all ecosystems, including agricultural land, but they were spread most widely in urban areas and grasslands, indicating the need for effective pest (weed) control in these areas. Invasive species pose significant threats to native biodiversity and ecosystems, and hence also on ecosystem services. The impacts of invasive alien species on biodiversity and ecosystem services are complex and often take substantial time to become evident.

Risk assessments to determine the potential environmental, social and economic impacts of invasive species are essential to inform their inclusion on the list of "Union concern". Assessing the condition of invaded ecosystems can help to identify priority areas and the need for intervention measures. Croplands reported a 46.8% share of ecosystems affected by invasive alien species (% of total area) based on a list of 49 species of "Union concern". The reduction in availability of pesticides or restricted use may have implications for the control of invasive alien species.

Biodiversity and climate change

The Ecosystems Assessment concludes climate change is already affecting Europe. It indicates that the most serious climate change-related problems are occurring in the Mediterranean biogeographical region, (Hungary, Romania and Bulgaria) including more extreme droughts, lower effective rainfall and higher temperatures that risk increasing forest fires and resulting in further ecosystem degradation. The effects of climate change on ecosystems are wide ranging and are considered one of the key risk factors for biodiversity decline and are projected to increase significantly across all ecosystems.

Climate change has already negatively affected the agriculture sector in Europe, and this will continue to 2030. For example, changes in crop phenology have been observed, such as the advancement of flowering and harvest dates in cereals[285]. These changes are expected to continue in many regions, leading to reductions in grain yield. There are also implications for pest prevalence and changing pressures on crop production. A reduction in the range of pesticides and use may have implications for the control of changing pest pressure and natural pest control under climate change.

A warming climate is leading to changes in species distribution and causing shifts in their ranges as well as phenological changes, which may lead to decreased food availability and increased

[280] Bremmer J, Deacon S, Alvarez L, Arts G, Huiting H, Smit B. Impact Assessment Framework with Specific Protection Goals (SPGs) for Non-Target Terrestrial Plants (NTTPs). Wageningen Economic Research; 2020.

[281] Haddaway, N.R., Brown, C., Eggers, S., Josefsson, J., Kronvang, B., Randall, N. and Uusi-Kämppä, J., 2016. The multifunctional roles of vegetated strips around and within agricultural fields. A systematic map protocol. Environmental Evidence, 5(1), pp.1-11.

[282] Hackett, M. and Lawrence, A., 2014. Multifunctional role of field margins in arable farming. CEA report. Cambridge Environmental Assessments.

[283] Holden J, Grayson RP, Berdeni D, Bird S, Chapman PJ, Edmondson JL, Firbank LG, Helgason T, Hodson ME, Hunt SF, Jones DT. The role of hedgerows in soil functioning within agricultural landscapes. Agriculture, Ecosystems & Environment. 2019 Mar 1;273:1-2.

[284] Deacon, S., Norman, S., Nicolette, J., Reub, G., Greene, G., Osborn, R. and Andrews, P., 2015. Integrating ecosystem services into risk management decisions: Case study with Spanish citrus and the insecticide chlorpyrifos. Science of the Total Environment, 505, pp.732-739.

[285] (Maes et al, 2020)

competition, and changes in species interlinkages and relationships. Climate change increases the importance of migration corridors between ecosystems and between protected areas. However, there are many barriers to movement, and not all species are able to move fast enough to keep up with the pace of climate change. With climate change, the conservation and sustainable use of genetic diversity has become more critical than ever. For example, plants and animals that are genetically tolerant of high temperatures or droughts, or resistant to pests and diseases, are of great importance in climate change adaptation, which requires a diverse genetic basis[286]. This also extends to agricultural crops in preserving plant varieties and pollinators for increased resilience to climate change.

Future climate change might also have some positive effects on the sector due to longer growing seasons and more suitable crop conditions. Climate change is projected to improve the suitability of northern Europe for growing crops, but the magnitude is uncertain. However, the number of climate extreme events negatively affecting agriculture in Europe is projected to increase and adversely affect overall biodiversity[287]. Furthermore, effects will differ between crop types, depending on short- and long-term adaptation effort[288].

Biodiversity and organic farming

Organic farming has increased in the last decade, reaching 7% of the utilised agricultural area. However, this has not been sufficient to prevent further erosion of biodiversity.

Organic farming focuses on sustainability and a meta-analysis shows that in some conditions organic agriculture comes close to matching conventional agriculture in terms of yields, while in other cases at present it does not[289]. Many agro-ecological farming systems – such as organic farming – are inherently more diverse, relying on rotations and mixed farming. Looking at the different types of farms and farming systems, there is often an inverse association between farming yields and biodiversity[290]. Greater yields typically arise from greater intensification: increased planting density, increased use of machinery, increased use of inputs (e.g., pesticides), and increased specialisation. In general, intensification reduces biodiversity. Some innovative agro-ecological approaches aim to maximise yields and minimise the impact on biodiversity. However, in general, the yield–biodiversity relationship means that nature-friendly farming systems tend to be lower-yielding than intensive farming systems (a review of the data most available worldwide suggests that organic yields may be, on average, 75% of conventional intensive systems).

Some commentary from the Slow Food Movement [291] highlighted that obtaining the EU organic logo is not always financially feasible (or interesting) for small-scale farmers, due to the costly certification process. Also, additional measures should be taken to promote agroecological practices that go beyond organic, and which also focus on biodiversity, seasonality, reducing mechanisation and shortening supply chains.

[286] Gitz V, Meybeck A, Lipper L, Young CD, Braatz S. Climate change and food security: risks and responses. Food and Agriculture Organization of the United Nations (FAO) Report. 2016;110.

[287] Jacobs C, Berglund M, Kurnik B, Dworak T, Marras S, Mereu V, Michetti M. Climate change adaptation in the agriculture sector in Europe. European Environment Agency (EEA); 2019.

[288] European Environment Agency (2017). Climate change, impacts and vulnerability in Europe 2016 - An indicator-based report.

[289] Seufert, V., Ramankutty, N. and Foley, J. A. (2012), 'Comparing the yields of organic and conventional agriculture', Nature, 485: pp. 229–32.

[290] Gabriel, D., Sait, S. M., Kunin, W. E. and Benton, T. G. (2013), 'Food production vs. biodiversity: comparing organic and conventional agriculture', Journal of applied ecology, 50(2): pp. 355–64.

[291] Slow Food Europe (2021), What do the new EU Farm to Fork and Biodiversity Strategies mean for slow food?

Landscapes: Land sharing or land sparing

Agriculture requires changing ecosystems from their natural state into a managed state and the more food the system must produce, the less suitable it becomes as habitat for wildlife (Benton et al, 2021). Broadly speaking, to produce a given amount of food (or biofuel crop), a large area of land can be used and farmed in a more wildlife-friendly way (but with smaller yields per area), or a smaller area of land can be used and the area farmed more intensively (with larger yields per area). This is the essence of the 'land-sharing' vs 'land-sparing' debate, which seeks to understand how best to integrate the needs of wildlife alongside the use of land for agriculture[292]. The most appropriate strategy depends on three factors: (1) how much more beneficial natural ecosystems are for biodiversity relative to nature-friendly farming systems; (2) the degree to which spill over effects (such as pesticide application) can be minimised; and (3) governance of the spared land (including its amount, type, location and protection). Many studies have now shown that in principle land-sparing can be more effective for biodiversity conservation[293] and is potentially better for other aspects of sustainability.

Simultaneously enhancing ecosystem services provided by biodiversity below and above ground is recommended to reduce dependence on chemical pesticides in agriculture; however, consequences for crop yield have been poorly evaluated. Above ground, increased landscape complexity is assumed to enhance biological pest control. In a field experiment replicated in 114 fields across Europe, a study found that fertilisation had the strongest positive effect on yield but hindered simultaneous harnessing of below- and above-ground ecosystem services. Furthermore, they showed that enhancing natural enemies and pest control through increasing landscape complexity can prove disappointing in fields with low soil services or in intensively cropped regions. Thus, understanding ecological interdependences between land use, ecosystem services and yield is necessary to promote more environmentally friendly farming by identifying situations where ecosystem services are maximised and agrochemical inputs can be reduced[294, 295].

The European State of the Environment (2020) reported structural parameters characterising farmland (crop diversity, high nature value farmland) have remained stable to 2020 at around the 2010 level, as has the share of agroecosystems under protection by EU and national legislation. Although the targets in the EU Biodiversity Strategy are heading in a positive direction for biodiversity, the targets are modest and without implementation of the EU Biodiversity Strategy through the CAP or other policy incentives relating to land management (e.g., land sparing or sharing), it is likely that little will change to 2030, i.e. declining biodiversity will continue.

10.1.4.3 *Predicted impacts of the pesticide targets in the Farm-to-Fork Strategy on biodiversity and landscapes*

It is uncertain what the influence of the pesticide targets in the Farm-to-Fork Strategy would be to biodiversity as it is likely to vary (as does biodiversity naturally), but ultimately the greater influence

[292] (Benton et al, 2021)

[293] Balmford, A., Amano, T., Bartlett, H., Chadwick, D., Collins, A., Edwards, D., Field, R., Garnsworthy, P., Green, R., Smith, P., Waters, H., Whitmore, A., Broom, D. M., Chara, J., Finch, T., Garnett, E., Gathorne-Hardy, A., Hernandez-Medrano, J., Herrero, M., Hua, F., Latawiec, A., Misselbrook, T., Phalan, B., Simmons, B. I., Takahashi, T., Vause, J., Ermgassen, E. and Eisner, R. (2018), 'The environmental costs and benefits of high-yield farming', Nature Sustainability 1(9): pp. 477–85.

[294] Gagic V, Kleijn D, Báldi A, Boros G, Jørgensen HB, Elek Z, Garratt MP, de Groot GA, Hedlund K, Kovács-Hostyánszki A, Marini L. Combined effects of agrochemicals and ecosystem services on crop yield across Europe. Ecology Letters. 2017 Nov;20(11):1427-36.

[295] Landis DA. Designing agricultural landscapes for biodiversity-based ecosystem services. Basic and Applied Ecology. 2017 Feb 1;18:1-2.

is likely to be changes in land use and other baseline factors, then how these may be mitigated by other aspects of the EU Biodiversity Strategy (and related policies).

If the assumption that one-third of CfS active ingredients would be substituted over the next decade (section 10.1.3), then it may mean an additional 20% of active ingredients may be restricted or withdrawn if the F2F target of 50% reduction in the most hazardous pesticides is met. These may or may not be for environmental reasons. The European Ecosystems Assessment concludes that reversing negative trends in agro-ecosystems will depend on reducing key pressures that are still high, particularly in terms of nutrient and pesticide use. However, it is unlikely that even these measures will be insufficient to 'bend the curve' on biodiversity loss. The European State of the Environment report predicted ongoing biodiversity decline in agricultural lands to 2030 caused by low diversity in habitat and food sources as well as human interaction in ecosystems.

Biodiversity conclusions

The main conclusions are summarised below:

- The reversal in the decline in biodiversity on agricultural land and the sustainable use of pesticides is only likely to succeed when supported by other effective policies, such as incentivisation through CAP payments for restoration and biodiversity enhancement.
- The impacts of pest control on biodiversity (either through pesticide use alone or IPM) can be quantified and measures should be put into policy to compensate for the impacts of crop production and pest control.
- The State of the Environment report concludes that measures introduced in the CAP through agri-environmental schemes to reduce the environmental impact of agriculture have brought some positive outcomes, including effective buffering of sprayed areas to reduce impacts of pesticides on biodiversity[296]. Overall, however, these have not been sufficient to halt biodiversity loss.
- The CAP's other measures have been less successful. For example, greening measures accounted for 30 % of the direct payments budget, introduced in the 2013 CAP for biodiversity, soil quality and carbon sequestration, but have been shown to be ineffective[297], leading to positive changes in farming practices on only 5 % of EU farmland.
- The European Commission has stated a 'business as usual' trajectory for the agriculture sector is likely to fail without full alignment with United Nations Sustainable Development Goals, including an increase in expenditure on sustainable development priorities and at the same time the phasing out of spending that is not in line with these priorities. The Commission's Green Deal, as well as the strategies for sustainable food and biodiversity protection, can provide a common direction of travel at EU level – but only if the EU has clearly defined 2030 targets as to where the agriculture, forestry and wider food sectors must make an active and measurable contribution[298]. This includes the sustainable use of pesticides.
- The additionality of the pesticide targets in the F2F Strategy are unlikely to have a substantial influence on biodiversity and landscapes. The Ecosystems Assessment[299] reports habitat change, including loss and fragmentation, have had the greatest overall impact on ecosystem services and they appear to be on the increase in more than 60 % of ecosystems assessed.

[296] Aguiar, T.R, Jr., Bortolozo, F.R., Hansel, F.A., Rasera, K., and Ferreira, M.T. (2015). Riparian buffer zones

325 and pesticide filters of no-till crops. Environmental Science and Pollution Research 22: 326 10618.

[297] (European Court of Auditors, 2017)

[298] https://ec.europa.eu/environment/soil/soil_policy_en.htm

[299] (Maes et al, 2020)

10.1.5 *Soil quality*

Soil is a vital asset to farmers. When soils are healthy, they contribute to healthier crops. Soil is composed of mineral particles, organic matter, water, air and living organisms. Soil is in fact an extremely complex, variable and living medium, but absolutely critical for life on Earth. It hosts 25% of the world biodiversity, it contains around twice the amount of carbon that is found in the atmosphere and three times the amount found in vegetation, and some 95% of our food is directly or indirectly produced from our soils. It is an essential ecosystem that delivers valuable services such as the provision of food, energy and raw materials, carbon sequestration, water purification, nutrient regulation, pest control, and support for biodiversity and recreation. Soil serves as a platform for human activities and landscapes, but its formation is an extremely slow process and may be considered as a non-renewable resource.

Many definitions of soil quality exist and generally incorporate biological, physical and chemical components. In a recent review undertaken by Bünemann et al (2018), indicators and approaches to soil quality assessment were recommended that focus on soil functions and ecosystem services, while a study by Thomson et.al[300] recommended more than 70 indicators of soil quality. Common indicators include organic matter, pH, available phosphorus and water storage, but recommendations are made by Bünemann et al (2018) to include more biological/biodiversity indicators, some of which would tie in well with ecotoxicological testing in PPP regulatory risk assessment and could lead to more relevant functional testing and monitoring of soil ecosystems.

Another important parameter to consider when assessing soil quality is soil organic carbon, especially with the focus on the climate crisis and the opportunities that soil ecosystems bring for carbon sequestration in climate mitigation. Also, measures that relate to the maintenance of soil structure and water cycling are important when, for example, farmers shift from traditional pesticide application regimes to wider uptake of IWM and mechanical weed management. For example, use of tillage implements like harrows and weeders can have detrimental effects, such as releasing carbon from the soil, lowering soil organic matter, soil compaction and other impacts, leading to increased soil erosion, fuel consumption/climate warming, leaching of plant nutrients and nutrient/pesticide runoff into waterbodies. There can be conflict between short-term pressures to maximise monetary returns through intensive soil cultivation and high yields in agriculture, and long-term sustainability of the soil. The ability of soil to produce ecosystem services offer benefits to society as a whole. This is also reflected in the EU Soil Strategy for 2030[301].

10.1.5.1 *Drivers of soil quality*

Drivers of impacts to soil quality are presented in Table 10.1 Some drivers that are specific to soil quality include crop cover, mulching, intercropping, cultivar mixtures, fallow land, slope and erosion potential; soil compaction; soil type (and depth); soil organic carbon content; water holding capacity; habitat loss and decline in biodiversity, including soil sealing, particularly through urban expansion into agricultural land and wider countryside; and soil policies, such as the EU Soil Thematic Strategy.

Land degradation is a global problem, often caused by a combination of factors such as poor land management, unsustainable agricultural practices, pollution and deforestation. The EU suffers from different levels of land degradation, with 13 EU Member States having declared themselves as affected Parties under the United Nations Convention to Combat Desertification (UNCCD), to which

[300] Thomsen M, Faber JH, Sorensen PB. Soil ecosystem health and services–Evaluation of ecological indicators susceptible to chemical stressors. Ecological Indicators. 2012 May 1;16:67-75.

[301] EU Commission. EU Soil Strategy for 2030. Reaping the benefits of healthy soils for people, food, nature and climate. COM(2021) 699 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0699

the EU itself is also party since 1998. The loss of agricultural land in the EU also increases the demand for agricultural imports which drives deforestation in countries exporting to the EU.

In the EU, land and soil will continue to be degraded, without policy intervention, by a wide range of human activities, often acting in combination. In the absence of a dedicated legislative framework, EU soil protection policy is shaped by the EU Soil Thematic Strategy and provisions in several new policy instruments, such as, the EU Biodiversity Strategy, the EU Forest Strategy and the revised CAP[302]. The PPP Regulation (EC) No 1107/2009 and the SUD aim to protect soils from the potential adverse impacts of PPP use or misuse, although no specific or coordinated monitoring programmes exist for European soils.

Monitoring programmes can be drivers for change though. A new European Soil Observatory (ESO) will streamline soil monitoring and indicator development in the European Commission (e.g. LUCAS SOIL) with the national activities of Member States, ongoing activities of the European Environmental Agency (EEA) and UN agencies (e.g. FAO Global and European Soil Partnership) into a single coherent system. The eventual system will extend to the current European Soil Data Centre (ESDAC) for use by the DG ENV, DG CLIMA, DG AGRI, DG SANTE and others. The ESO will report on the main threats to soil health as listed in the EU Soil Thematic Strategy: Soil erosion, soil organic matter decline, soil contamination, soil sealing, soil compaction, soil acidification, soil salinization, soil biodiversity loss, landslides and mass movements[303].

In addition, research programmes such as the European Joint Programme on Agricultural Soil Management (EJP SOIL) will inform knowledge of European soil quality. The objectives are to develop knowledge, tools and an integrated research community to foster climate-smart sustainable agricultural soil management that allows sustainable food production, sustainable soil biodiversity, and sustainable soil functions that preserves ecosystem services.

10.1.5.2 *Estimated changes in soil quality in the Baseline Scenario*

The European Ecosystem Assessment reported that the main pressures on agricultural soils - use of pesticides and gross nitrogen balance - have remained stable over the last 10 years, so has the structural condition of agroecosystems (measured by indicators including landscape mosaic, crop diversity). However, the report states that almost 600 km^2 of agroecosystems are lost each year due to soil sealing. Agricultural soils are being lost to urban expansion and degraded by intensive agriculture practices resulting in soil compaction, contamination, loss of organic matter and biodiversity, with increased soil erosion. Croplands and grassland soils exhibit a slight decrease in soil organic carbon stocks between 2009 and 2015 of about 0.06% and 0.04% respectively, but with marked regional differences[304]. These trends are set to continue to 2030 without policy intervention and deteriorating developments dominating. The Ecosystems Assessment concludes that reversing negative trends in agroecosystems will depend on reducing key pressures that are still high, particularly in terms of nutrient and pesticide use.

The European State of the Environment report (2020) concurs. Land take and soil sealing continue, predominantly at the expense of agricultural land, reducing its production potential. While the annual rate of land take and consequent habitat loss has gradually slowed, ecosystems are still under pressure from fragmentation. European policy aims to develop the bioeconomy but while new uses for biomass and increasing food and fodder consumption require increasing agricultural output, land for agricultural use has decreased. This leads to growing pressures on the available agricultural

[302] https://ec.europa.eu/environment/soil/index_en.htm

[303] Montanarella, L. and Panagos, P., 2021. The relevance of sustainable soil management within the European Green Deal. Land Use Policy, 100, p.104950.

[304] (Maes et al, 2020)

land and soil resources which are exacerbated by the impacts of climate change. The outlook in the report is one of deterioration in land and soil quality to 2030.

The influence of pesticide use on soil quality is difficult to disentangle from other agricultural management techniques. The control of weeds and other pests in the crop habitat will continue to lead to some loss in non-target organisms within the treatment area. However, the continued use of pesticides in combination with other measures as part of an IPM strategy may provide the best outcome for soil quality[305]. For example, ploughing less will reduce the physical impact on soil organisms important for maintaining soil quality. Stroud (2019)[306] showed that most fields have basic earthworm presence and abundance, but 42% of fields may be over-worked as indicated by absence or scarcity of epigeic and/or anecic earthworms[307]. Tillage is an IPM method for controlling weeds but had a negative impact ($p < 0.05$) on earthworm populations. Organic matter management did not mitigate tillage impacts. These impacts are unrelated to pesticide impacts (no correlation could be made in the study) and would continue in the baseline scenario. The use of specific herbicides and precision technology for targeted application, as part of an IWM strategy, does bring environmental and economic benefits[308].

The European State of the Environment report (2020) states residues of PPP may reside in soils and will continue under the baseline scenario. Substances that are not readily degradable will eventually leach into surface and groundwaters or be dispersed by wind erosion (Silva et al, 2018). There is increasing concern about the residence and accumulation of pesticide residues and their metabolites in soils, and their potential release mechanism[309]. In Finnish agricultural soils, 43% of the samples contained pesticides, while quality standards were exceeded in 15% of the groundwater bodies studied. In a pilot study with Land Use and Coverage Area Frame Survey (LUCAS) soil samples, over 80% of soils tested contained pesticide residues, with 58% of samples containing mixtures of two or more residues in a total of 166 different pesticide combinations. The European Environment Agency concludes that these results indicate the accumulative effects of pollutants, and that mixtures of pesticide residues in soils are the rule rather than the exception, suggesting that the filtering capacity of soils has been exceeded in some areas. This will continue under the baseline scenario, and the additive effects are still unknown for many combinations of substances in soils.

The CAP reform has been referred to as a 'greening' of agriculture with an obligation on larger farms to have at least 5% of the arable area on their farm as 'ecological focus areas (EFAs)'. The options for EFAs include cover crops, catch crops, buffer strips and field margins, hedgerows and trees, nitrogen-fixing crops and fallow land. A European Commission report (2017) [310] showed that after two years of implementation the methods had minimal impact. This is a short timeframe for soils, whereas changes to land management for protection of soil quality may realise measurable benefits over a 10-year timeframe.

[305] Bremmer J, Deacon S, Alvarez L, Arts G, Huiting H, Smit B. Impact Assessment Framework with Specific Protection Goals (SPGs) for Non-Target Terrestrial Plants (NTTPs). Wageningen Economic Research; 2020.

[306] Stroud JL (2019) Soil health pilot study in England: Outcomes from an on-farm earthworm survey. PLoS ONE 14(2): e0203909

[307] Epigeic earthworms break down surface crop residues and their presence is linked to the breeding season success rates of the song thrush (*Turdus philomelos*), the latter whose populations have rapidly declined in England. Anecic earthworms incorporate surface organic matter into the soil, support water drainage for plant production and deep crop rooting.

[308] (Bremmer et al, 2020).

[309] (Silva et al, 2019)

[310] EC (2017). Evaluation Study of the Payment for Agricultural Practices Beneficial for the Climate and the Environment. Alliance Environment and the Thünen Institute.

Maximising yields over the short term may reflect a market failure to cater for longer-term soil sustainability, as a result of which society loses the common goods and services when soils and their natural capital are neglected. Addressing this requires recognition that protecting the value of soil needs long-term investment as soil fertility and soil carbon take decades to build[311] . The values of soil capital also need a mechanism through which they can be transferred to farmers and their profits with appropriate incentives, such as payment for ecosystem services. Such incentives are partly present in the CAP but not yet implemented to a degree that ensures healthy and sustainable soils, thereby soil quality is predicted by EASAC to continue to decline in the baseline scenario.

Soils and organic farming

The F2F target of 25% organic farming in Europe by 2030 may hold more promise for soil quality. A review of global organic farming practices demonstrated that organically managed soils have significantly higher levels of organic matter than those managed non-organically, and in North-West Europe an average increase of 21%[312]. An annual incremental increase of 1% soil organic matter content appears an achievable target for organic farms.

An example of the legacy of pesticide use versus organic farming systems in Europe is provided in a study by Geissen et al (2021)[313]. A total of 340 EU agricultural topsoil samples were tested for multiple pesticide residues. These samples originated from four crops and three Member States collected between 2015 and 2018. Soils from conventional farms presented mostly mixtures of pesticide residues with a maximum of 16 residues/sample. Soils from organic farms had significantly fewer residues with a maximum of 5 residues/sample. The residues with the highest frequency of detection and the highest content in soil were herbicides. Organic soils presented 70-90% lower residue concentrations than the corresponding conventional soils. This would indicate that the F2F Strategy of more farm conversions to organic status would in the long-term see a reduction in soil organism (especially plants) exposure to pesticide residues. It also shows that despite the targets, true organic status of European farm soils may take time to achieve.

A similar US study screened 100 fields under organic and conventional management with an analytical method containing 46 pesticides (16 herbicides, 8 herbicide transformation products, 17 fungicides, seven insecticides). Pesticides were found in all sites, including 40 organic fields. The number of pesticide residues was two times and the concentration nine times higher in conventional compared to organic fields. Pesticide number and concentrations significantly decreased with the duration of organic management, however, even after 20 years of organic agriculture up to 16 different pesticide residues were present. Microbial biomass and specifically the abundance of arbuscular mycorrhizal fungi, a widespread group of beneficial plant symbionts, were significantly negatively linked to the amount of pesticide residues in soil. The authors concluded that pesticide residues, in addition to abiotic factors such as pH, are a key factor determining microbial soil life in agroecosystems and demonstrates that pesticides are a hidden reality in agricultural soils with the potential for harmful effects on beneficial soil life[314].

However, there is a note of caution. Inorganic substances marketed for organic farming, such as copper-based products, can impact soil quality and persist in the soil environment. Excess copper

[311] EASAC, 2018. Opportunities for soil sustainability in Europe. EASAC policy report 36 September 2018 ISBN: 978-3-8047-3898-0

[312] Soil Association (2021). Seven ways to save our soils.

[313] Geissen V, Silva V, Lwanga EH, Beriot N, Oostindie K, Bin Z, Pyne E, Busink S, Zomer P, Mol H, Ritsema CJ. Cocktails of pesticide residues in conventional and organic farming systems in Europe–Legacy of the past and turning point for the future. Environmental Pollution. 2021 Jun 1;278:116827.

[314] Riedo J, Wettstein FE, Rösch A, Herzog C, Banerjee S, Büchi L, Charles R, Wächter D, Martin-Laurent F, Bucheli TD, Walder F. Widespread occurrence of pesticides in organically managed agricultural soils—the ghost of a conventional agricultural past?. Environmental Science & Technology. 2021 Feb 3;55(5):2919-28.

concentrations are recognised as having phytotoxic effects on the growth and development of plants, adverse effects on soil microbes and some groups of soil fauna, such as the collembola (springtails) and long-term toxicity to earthworms[315]. Copper has been widely used as a fungicide spray, especially in vineyards and orchards. Results from the Land Use and Coverage Area Frame Survey (LUCAS) soil sampling 2009-2012 show elevated copper levels in the soils in the olive and wine-producing regions of the Mediterranean[316]. The example of copper as an alternative 'organic approach' may have similar consequences for soil quality as the 'most hazardous' synthetic pesticides.

Soils and climate mitigation

Climate change will influence soil quality in agroecosystems over the next 10 years. Damaging periods of summer drought are likely to become more frequent, especially in southern European countries, and drier soil conditions will reduce growth of crops, pasture and trees (agriculture and forestry). The recent workshop on tackling the biodiversity and climate crises hosted by IPBES reported the need for measures such as diversification of planted crop and forest species, agroforestry and agroecology, and soil conservation could offer annual climate change mitigation potential of 3 to 6 gigatonnes of carbon dioxide equivalent (globally).

Mitigating climate change through building soil carbon is an appealing way to increase carbon sinks and reduce emissions owing to the associated benefits to agriculture. However, the practical implementation of soil carbon climate strategies lags behind the potential, partly because we lack clarity around the magnitude of opportunity and how to capitalise on it. Global soil carbon represents 25% of the potential of natural climate solutions, of which 40% is protection of existing soil carbon and 60% is rebuilding depleted stocks. Soil carbon comprises 9% of the mitigation potential of forests, 72% for wetlands and 47% for agriculture and grasslands. Soil carbon is important to land-based efforts to prevent carbon emissions, remove atmospheric carbon dioxide and deliver ecosystem services in addition to climate mitigation[317]. In a cross-EU study of 114 arable wheat fields, the fields with higher levels of organic matter had the co-benefit of requiring less fertiliser to produce an effect on crop yield[318].

IPM strategies that lead to the prevention of carbon emissions and carbon capture in soils should be promoted through the SUD. For example, cover cropping leads to soil quality and fertility enhancement, reducing agricultural water demands with appropriate cover crops, reducing soil erosion and redistribution, and maintaining soil depth and water retention[319]. Strategies that lead to carbon emissions, such as ploughing, should be minimised. This can be achieved without the influence of the pesticide targets in the F2F Strategy (i.e. the baseline scenario).

Climate change is also leading to heavy rainfall and extreme weather events, as unfortunately seen recently in July 2021 in western Europe. While the introduction of management practices over the last decade – including reduced tillage, cover crops and grass margins – appear to have resulted in

[315] Andrivon D., Bardin M., Bertrand C., Brun L., Daire X., Fabre F., Gary C., Montarry J., Nicot P., Reignault P., Tamm L., Savini I., 2018. Can organic agriculture give up copper as a crop protection product? Condensed report of the Scientific collective assessment, INRA, 66 p.

[316] Ballabio C, Panagos P, Lugato E, Huang JH, Orgiazzi A, Jones A, Fernández-Ugalde O, Borrelli P, Montanarella L. Copper distribution in European topsoils: An assessment based on LUCAS soil survey. Science of The Total Environment. 2018 Sep 15;636:282-98.

[317] Bossio DA, Cook-Patton SC, Ellis PW, Fargione J, Sanderman J, Smith P, Wood S, Zomer RJ, Von Unger M, Emmer IM, Griscom BW. The role of soil carbon in natural climate solutions. Nature Sustainability. 2020 May;3(5):391-8.

[318] Gagic V, Kleijn D, Báldi A, Boros G, Jørgensen HB, Elek Z, Garratt MP, de Groot GA, Hedlund K, Kovács-Hostyánszki A, Marini L., 2017. Combined effects of agrochemicals and ecosystem services on crop yield across Europe. Ecology Letters. Nov;20(11):1427-36.

[319] (Bossio et al, 2020).

lower soil erosion from water, the area affected remains significant. The Institute of European Environmental Policy recently estimated that an area larger than Greece is affected[320]. The latest estimates show that approximately 11.4% of the EU's territory is affected by moderate to severe soil erosion from water (up to 5 tonnes of soil per hectare per year), including about 12.5 % of arable land equating to an area of 138 200 km² (larger than the size of Greece). Furthermore, losses in crop productivity related to soil erosion from water alone are estimated to cost the EU agricultural sector around 1.25 billion euro annually. These events have consequences for water quality as eroded soils lead to sedimentation of water bodies and, if weather events closely follow pesticide applications, may lead to contamination of waterbodies from pesticides in rainfall runoff.

10.1.5.3 *Predicted impacts of the pesticide targets in the Farm-to-Fork Strategy on soil quality*

A reduction in 50% of the most hazardous pesticides target in the Farm-to-Fork Strategy, where this has the potential to affect non-target terrestrial plants, soil fauna and soil microbial process, is likely to be beneficial for soil biodiversity. However, it is unlikely that the pesticide targets will alone improve soil quality when a range of biological and physico-chemical indicators of soil quality are considered. The example given above of an increase in mechanical weeding or more frequent applications of lower hazard pesticides (which may be less efficacious) to compensate for a reduction in more hazardous pesticides may lead to soil compaction, increased soil erosion from reduced infiltration and increased runoff from overland flow, greater disturbance and mortality of surficial soil biodiversity, and if yields decline without other policy instruments to support farming, then detrimental land use changes too (e.g. deforestation, drainage of wetlands and conversion of permanent grasslands into arable land, including outside the EU). The JRC[321] compiled a map showing the vulnerability of European soils to compaction. Current drivers of soil compaction include the increased wheel pressure of heavier agricultural machinery. Soils are especially vulnerable to compaction when waterlogged, or otherwise in poor condition. Again, reductions in the most hazardous pesticides are unlikely to lessen soil compaction but may instead increase it as alternative methods relying on heavy machinery may be used more frequently in pest control.

The European State of the Environment report (2020) confirmed an annual decline in agricultural land and habitat loss resulting in a negative outlook to 2030 for agricultural land and soils. This is working against the aspiration for less intensification in crop production, which puts greater pressure on remaining agricultural land to work harder. In its report, the European Environment Agency referred to pesticide residues being found in almost half of Finland's soils and across Europe, and that the accumulative effects or mixtures toxicity of pesticide residues in soils are unknown. Even if the reduction in pesticide targets is met in the F2F Strategy, it is likely that residues will be found in soil for some years (as in waterbodies – see chapter 10.1.6 Water Quality).

A more optimistic view is reported by the CAPRI model[322]. A relative contribution of the different Farm-to-Fork targets to the reduction in greenhouse gas (GHG) emission was modelled and concluded the greatest contributions are led by the nutrients and pesticide targets. In addition, the organic area target also has a significant impact on total GHG contribution due to the assumed increase in cover crop use, which increases the carbon content in soils.

[320] https://ieep.eu/news/world-soil-day-highlights-urgency-for-eu-action-on-improving-the-health-of-our-soils?utm_campaign=coschedule&utm_source=twitter&utm_medium=IEEP_eu

[321] JRC, 2015. Soil threats in Europe, technical report. Status, methods, drivers and effects on ecosystem services

[322] Barreiro-Hurle, J., Bogonos, M., Himics, M., Hristov, J., Pérez-Domiguez, I., Sahoo, A., Salputra, G., Weiss, F., Baldoni, E., Elleby, C. Modelling environmental and climate ambition in the agricultural sector with the CAPRI model. Exploring the potential effects of selected Farm to Fork and Biodiversity strategies targets in the framework of the 2030 Climate targets and the post 2020 Common Agricultural Policy, EUR 30317 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-20889-1, doi:10.2760/98160, JRC121368

Soil quality conclusions

The main conclusions are summarised below:

- The outlook in the State of the Environment report is one of deterioration in land and soil quality to 2030.
- The European Ecosystem Assessment (European Union, 2021) reported that one of the main pressures on agricultural soils - use of pesticides - has remained stable over the last 10 years, so has the structural condition of agroecosystems (measured by indicators including landscape mosaic, crop diversity). However, the European Ecosystem Assessment and European State of the Environment reports concur that agricultural soils are being lost to urban expansion (soil sealing) and degraded by intensive agriculture practices resulting in soil compaction, contamination, loss of organic matter and biodiversity, with increased soil erosion.
- Growing pressures on the available agricultural land and soil resources are exacerbated by the impacts of climate change, although substantial opportunities for climate mitigation are available through carbon sequestration and storage in agricultural soils.
- It is expected that restrictions in use would continue in the baseline scenario to 2030 through the Candidates for Substitution approach under Regulation (EC) No 1107/2009 and be influenced by effects on soil organisms, however, priority substance pesticides or newly restricted pesticides may persist in soil systems to 2030 (and possibly beyond), even in organic soil ecosystems. There are uncertainties around mixture toxicity and the potential for combined effects of pesticides and other chemicals on soil systems.
- The additionality of the reduction in 50% of the most hazardous pesticides target in the Farm-to-Fork Strategy - where these have the potential to affect non-target terrestrial plants, soil fauna and soil microbial process - is likely to be beneficial for soil biodiversity. However, it is unlikely that the pesticide targets alone will improve soil quality when a range of biological and physico-chemical indicators are considered.

10.1.6 Water quality

Using pesticides protects crops and maintains yields, but pesticides applied to crops, under certain conditions such as heavy rainfall after application, can enter surface and ground water where they may adversely affect plants and animals and may contribute to biodiversity loss in aquatic ecosystems[323]. It is noted that the indicator for water excludes the availability of water resources (water quantity), although water resources may change if pesticide contamination exceeds drinking water standards and renders a waterbody (e.g. groundwater aquifer) 'contaminated' and unavailable for drinking water abstraction. The issue of water scarcity for crop irrigation, as a result of climate change, is generally the primary concern for agriculture when considering water quantity and outside the scope of this IA.

10.1.6.1 *Drivers of water quality*

Key drivers influencing water quality are summarised in Table 10.1 with the drivers that may be particular to water quality listed below:

- Protection of groundwater aquifers/drinking water sources
- Crop cover (runoff and percolation), mulching, intercropping, cultivar mixtures
- Slope
- Soil quality (and depth/bedrock for groundwater)
- Soil texture e.g. heavy clay soils compared to sandy soils

[323] European Court of Auditors (2020). Special report 15/2020: Protection of wild pollinators in the European Union - Commission initiatives have not borne fruit

- Buffer zones or field margins (proximity of water body)
- Water policies[324], e.g., Water Framework Directive (WFD), Groundwater Directive, Drinking Water Directive, Urban Wastewater Directive, and Floods Directive

There are several pathways that a pesticide can take to enter the aquatic environment, such as runoff in heavy rainfall. Environmental monitoring is important to confirm that there are no unacceptable effects or risks for the environment resulting from PPP use, and the EU focus is mainly on the aquatic environment.

Member States monitor active substances in water and can require PPP producers to monitor the effects of authorised PPPs, although the Commission does not have an overview of such monitoring. In practice, Member States mainly carry out environmental monitoring under other legislation, such as the WFD. Member States must monitor several active substances, and relevant residues in ground, surface and drinking water. For surface water, the EU defines substances that Member States must monitor; 36 of these are active substances, of which ten are currently approved for use in pesticide products. Member States must monitor additional substances beyond those specified by EU law, if emitted in significant quantities. For example, the Netherlands has an extensive water monitoring system and complements the monitoring of the EU defined substances with an additional 16 active substances deemed problematic in their surface waters (12 of which are currently approved for use in PPPs in the EU).

Several of the substances monitored in surface waters are no longer approved for use in PPPs but have only recently been non-approved and/or are still found there because of their persistence, illegal use, deposition from the atmosphere or leaching from landfills. A few are still produced in, or used for, other processes, e.g. industrial, biocides. In groundwater, Member States are obliged to monitor all relevant active substances in pesticides, including their metabolites, degradation and reaction products, and the concentrations have to be compared with quality standards for individual and total pesticides. The individual and total pesticide quality standards in the Groundwater Directive are also found in the Drinking Water Directive. Monitoring under that Directive can provide information on the presence and concentrations of pesticides.

Monitoring data is becoming increasingly important and part of the re-evaluation procedure of pesticides. However, risk managers must be aware that the use of monitoring data for this purpose has its limitations. The sampling of surface waters is not usually undertaken directly after the application of pesticides, when the highest entries by drift are expected to occur or after rain events, when the highest entries via runoff or drainage are generally occurring.

A review of pesticide reporting in river basin management plans (RBMP) could not conclude whether (i) reporting is correct — concerns about pesticides are overstated and measures have been effective; (ii) reporting is correct for reported substances, but there is a lack information on many other pesticides; or (iii) reporting of water bodies' status is inaccurate, owing to monitoring not reflecting the situation during peak periods of pesticide use. A study in Germany using the species at risk (SPEAR) index confirmed that pesticides were seldom found in routine monitoring, but when streams were sampled during heavy rainfall just after application or as composite samples, then pesticides were recorded more frequently.

In addition, the European Environment Agency review by Mohaupt et al (2020) analysed pesticide monitoring data to identify pesticide groups (herbicides, insecticides and fungicides) and substances (including metabolites) responsible for causing failure of the available thresholds. Their conclusion - the reported information on pesticides in Europe’s waters is currently insufficient to support a

[324] EC (2017) Commission Staff Working Document

thorough assessment of the risks posed. This situation represents a significant cause for concern in attempts to protect and improve water quality.

10.1.6.2 *Estimated changes in water quality in the Baseline Scenario*

Pesticides of concern are listed as priority substances in the Water Framework Directive (WFD 2013/39/EU). However, despite restrictions on use, priority substances are still found in routine regulatory monitoring by Member States at levels that exceed environmental quality standards under the WFD. There is some evidence of restrictions being effective, such as the European ban on atrazine has led to substantial declines in concentrations found in coastal waters (Nödler et al, 2013)[325], however, the herbicide was still being detected in some marine systems downstream of countries that banned its use in the 1990s, indicating a 10-year or more time lag for this particular active ingredient to breakdown.

According to the most recent review of European water body status, the European Environmental Agency[326] report on *"European waters – assessment of status and pressures"* reveals that 0.4 % of all surface water bodies fail good chemical status due to priority substance pesticides. A total of 6.5% of the area of groundwater bodies fail good chemical status because of pesticides. However, the European Environment Agency believes this is likely to be an underestimate as the real impact of pesticides on the aquatic environment is largely unknown or unrecorded due to limitations in current WFD reporting, which means the full range of active ingredients, metabolites and transformation products can remain unaccounted for in Europe-wide reports.

More specifically, the monitored data for European surface water between 2007 and 2017 records exceedances of quality standards of 5–15% by herbicides, 3–8% by insecticides, and negligible exceedances for fungicides. Whereas for groundwater, the exceedances of quality standards were about 7% for herbicides and below 1% for insecticides, whilst also being negligible for fungicides [327]. An exceedance of a water quality standard may indicate the potential for an adverse effect on aquatic ecology and may be viewed as a trigger for further assessment to determine whether a risk is realised.

The EU *Chemicals in European surface waters* reported the group with the highest sales were fungicides and bactericides (about 43%), followed by herbicides (35%) and insecticides (5%). However, fungicides and bactericides are not ranked highly in the lists of most frequently reported pesticides concurring with the outcome of EEA (2020) report that the full range of pesticides in the aquatic environment may be under-represented in WFD reporting.

In a recent review by Wolfram et al (2021)[328] on water quality and ecological risks in European surface waters, pesticides were identified as the main risk drivers (>85% of regulatory threshold level (RTL) exceedances) with aquatic invertebrates being most acutely at risk in Europe. In total, 352 organic contaminants, measured at 8,209 locations in 7,227 waterbodies for 31 countries between 2001 and 2015, were identified and assigned to major chemical classes including fungicides, herbicides and insecticides. The authors concluded acute ecological risks were mainly posed by insecticides (56.5%) and herbicides (27.4%). When this study is reflected against the EU Chemicals in European water report, it would appear that although insecticides represent a small

[325] Nödler K, Licha T, Voutsa D. Twenty years later–atrazine concentrations in selected coastal waters of the Mediterranean and the Baltic Sea. Marine pollution bulletin. 2013 May 15;70(1-2):112-8.

[326] Kristensen P, Whalley C, Zal FN, Christiansen T. European waters assessment of status and pressures 2018. EEA Report. 2018(7/2018).

[327] EEA, "ETC/ICM Report 1/2020: Pesticides in European Rivers, Lakes and Groundwaters - Data Assessment." EEA.

[328] Wolfram J, Stehle S, Bub S, Petschick LL, Schulz R. Water quality and ecological risks in European surface waters–Monitoring improves while water quality decreases. Environment International. 2021 Jul 1;152:106479.

proportion of pesticides sales (5%), they may be responsible for more than half of the acute risks to European aquatic invertebrate life. It would suggest that pesticide sales data, when used alone, are a poor indicator of environmental risk. Further research would inform the sources of these pesticides to direct risk management actions.

The European State of the Environment Report[329] reported that currently only 40% of Europe's surface water bodies achieve good ecological status and wetlands are widely degraded, as are 80-90% of floodplains. Agricultural land use was clearly identified in the EEA report as the primary spatial driver of the observed aquatic risks throughout European surface waters. This has a critical impact on the conservation status of wetland habitats and the species that depend on them. Although point source pollution, nitrogen surpluses and water abstraction have been reduced across Europe, freshwaters continue to be affected by diffuse pollution (pesticides), hydromorphological changes and water abstraction. Although pesticides are not identified in isolation, a decrease in pesticide use or a reduction in agricultural land (or related pressures) may help to improve degraded wetland and floodplain ecosystems to 2030.

Several studies have focussed on pesticide monitoring in surface waterbodies, for example:

- In a study of 345,000 pesticide measurements in surface waters in Switzerland, it was concluded that regulatory acceptable criteria were exceeded in small to medium surface waters, and these were mainly by herbicides and fungicides[330]. Fungicides dominated the detections, which differs from the Europe-wide monitoring studies collated by the European Environment Agency. Most of the exceedances were measured in surface waters surrounded by vineyards where fungicides are widely used. It was concluded that a few pesticides in use might account for most of the concern for aquatic life. The authors concluded that implementing further risk mitigation measures might be advisable to reduce the exposure in aquatic systems, although if action is not taken, then there may be an ongoing risk to aquatic systems in this region to 2030.
- In terms of understanding long-term trends (and how trends may continue to 2030), van Klink et al (2020)[331] evaluated changes in total insect abundance and biomass, as well as the geographic distribution of such changes from 1,676 sites from 166 studies spread over 41 countries and using data between 1925 to 2018. They found a 1.08% annual increase for freshwater insects, equalling +11.33% per decade. The mean trend estimates of insect abundance and biomass were similar, but differed in strength of evidence because of the lower data availability for biomass. The increasing trend for the freshwater insects, particularly in the temperate zone, is consistent with recent analyses from these regions and may at least partially reflect recovery from past degradation (e.g., the Clean Water Act and similar legislation). The trends became more positive with increasing crop cover. At the same time, the authors found an average increase in freshwater insect abundances that might, at least partially, reflect improvements in water quality over the last century. This, in combination with their finding that trends were weaker in protected areas, suggests that appropriate habitat protection and restoration may be effective strategies for mitigating changes in insect assemblages. There was no potential role of climate change in the data.
- Wolfram et al (2021) showed insecticides contribution to the overall risk profile of pesticides to the aquatic environment requires special attention because these substances are generally difficult to capture during monitoring efforts due to their fast dissipation rates. The authors conclude that detection frequencies and actual aquatic risks are not directly related, rather the

[329] EEA, 2020. "ETC/ICM Report 1/2020: Pesticides in European Rivers, Lakes and Groundwaters - Data Assessment,",

[330] Knauer, K., 2016. Pesticides in surface waters: a comparison with regulatory acceptable concentrations (RACs) determined in the authorization process and consideration for regulation. Environmental Sciences Europe, 28(1).

[331] Van Klink R, Bowler DE, Gongalsky KB, Swengel AB, Gentile A, Chase JM. Meta-analysis reveals declines in terrestrial but increases in freshwater insect abundances. Science. 2020 Apr 24;368(6489):417-20.

contrary appears to be the case, as insecticides, which are infrequently detected may define aquatic risks on a European scale[332]. It is noted that the Candidates for Substitution active ingredients may be considered Candidates based on environmental fate properties (persistence and bioaccumulation) that differ from the properties highlighted in Wolfram's study. The chemical classes driving acute ecological risk in surface waters, according to Wolfram et al (2021), differ considerably among organism groups. Threshold [of toxicity] exceedances in invertebrates and vertebrates are mainly driven by insecticides. Unsurprisingly in algae and plants, herbicides (and industrial chemicals) represent 95% of exceedances. From an ecosystem perspective, the authors state insecticides and herbicides are the primary risk drivers of *acute* toxicity, followed by industrial chemicals. The potential for chronic toxicity, which may be more relevant to more persistent pesticides, is not reported.

- A similar response by Underwood & Mole (2016)[333] suggested that states that withdrawals are a relatively simple solution to the problem of water quality infringements as only a few pesticides may be responsible for aquatic risk.
- An additional example from the Netherlands estimated that the removal of a small number of pesticide active substances in horticultural crops would reduce the risk to aquatic biodiversity associated with typical crop spray schemes by up to 80% (van Eerdt et al, 2014). Van Eerdt et al (2014) reviewed the effectiveness of voluntary IPM measures in 15 crops in the Netherlands. Of the 105 measures evaluated, the most effective measures with respect to risk reduction were emission reduction and replacement of high-risk pesticides (each up to 80% reduction). IPM measures directed towards lowering pesticide use generally showed a smaller risk-reducing potential and the number of pesticide applications hardly reduced, and therefore the dependence on chemical crop protection continued to be high. Pesticide substitutions have the potential to reduce impacts to aquatic biodiversity, although the targets need to be supported by other policy mechanisms in the SUD, such as education, availability of alternative pest control methods, and greater/targeted implementation of IPM.

As a summary, the European State of the Environment Report (2020) makes predictions to 2030 for the water environment by stating the outlook "shows a mixed picture", as follows:

- Diffuse pollution and water abstraction pressures are expected to continue in response to intensive agricultural practices and energy production.
- Improved implementation and increased coherence between EU water-related policy objectives and measures is needed to improve water quality and quantity. Looking ahead it will also become increasingly critical to address and monitor the climate-water-ecosystem-agriculture nexus and connection with energy needs.
- It is on the river basin scale that effective solutions for water management can be found, and essential knowledge is being developed through the implementation of river basin management plans under the Water Framework Directive. Solutions such as natural water retention measures, buffer strips, smart water pricing, more efficient irrigation techniques and precision agriculture will continue to grow in importance. An ecosystem-based management approach, considering multiple environmental objectives and co-benefits to society and the economy, will further support progress.

The European Environment Agency reports the second greatest pressure on the aquatic environment is from the use of pesticides (38% contribution to diffuse pollution)[334]. Whereas for

[332] (Wolfram et al, 2021)

[333] Underwood, E and Mole, N (2016). Effective policy options for reducing environmental risks from pesticides in the UK. Institute of European Environmental Policy.

[334] EEA, 2018. "European Waters. Assessment of Status and Pressures 2018. EEA Report No 7/2018,", https://www.eea.europa.eu/publications/state-of-water.

groundwater, agriculture is the main cause for failure to achieve good chemical status due to diffuse pollution from nitrates and pesticides. The European Environment Agency reported that Europe is not on track to meet policy objectives on water quality. It predicted a 'red light' warning in its outlook to 2030 based on continuing progress to restrict pesticide use, however, even reduced emissions will still contribute to further accumulation of persistent chemicals in the environment.

Drinking water

Observed concentrations of pesticides in drinking water resources are currently very low (EurEau, 2020). At current concentration levels, there is no definite scientific evidence of adverse effects on human health yet, however, as use of chemical and plant protection products increases, micropollutants might become a real challenge for water resources and for water services once they enter the water cycle. The EU Green Deal Zero Pollution ambition in line with the EU Treaties, where the Precautionary Principle is consistently applied, may be a stronger actor for preventive action to protect drinking water resources[335] than the SUD or pesticide targets in the F2F Strategy. It has not been possible to find a published or recent value for the costs of pesticide removal from drinking water resources in Europe, but industry stakeholders state them to be high and increasing. Recent figures from EurEau[336] state that the water treatment cost due to pesticides for Prague's main water treatment plant was EUR 50 million 2018-2020.

Few countries report pesticide emissions to water, and for only a few selected pesticides, so no picture is available for European trends in pesticide emissions. The substances reported vary for each country. Legacy pesticides threaten drinking water in Denmark and Spain. Pesticides were the major contributors to the chemical risk and were related to agricultural and urban areas in the upstream catchments. In a Netherlands study, pesticide concentrations exceed 75% of the pesticide standards in one third of the groundwater abstractions. Two thirds of the substances found were herbicides[337]. As noted in the previous section on soil quality, soils provide buffering service for the prevention of PPP percolation to water bodies, but – as indicated by the LUCAS study – if the filtering capacity of soils has been exceeded in some areas, this has implications for underlying groundwater bodies.

An example of a programme that shows promise for sustainable pesticide use to 2030 is the Better Bentazone Together initiative[338]. Bentazone is highly soluble in water and mobile in soil and has been regularly detected in both ground and surface water for many years. The initiative developed maps for farmers indicating the environmental sensitivity of their farms to the potential leaching of bentazone into waterbodies. The initiative is driven by the authorisation holders to work towards a rapid reduction of the current levels of contamination. This is done in order to safeguard the future of the active substance for weed control, requiring a responsible response from advisers and growers who may be called on to accept weeds in their crop rather than apply bentazone in a high-risk area. The advice continues by explaining how the product can transfer to waterbodies under certain weather conditions and advises no spray zones around field margins. The initiative exemplifies many aspects of the SUD, including farmer and adviser training and awareness raising, easy-to-use mapping tools, and working together as a collective crop protection industry for the benefit of the environment.

[335] EurEau, 2020. The governance of water services in Europe. 2020 edition.

[336] Presentation by EurEau at SUD 3rd stakeholder event, October 5 2021, available at https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/events/presentations/event_sante_pesticides_sud_20211005_pres_eureau.pdf

[337] Swartjes FA, Van der Aa M. Measures to reduce pesticides leaching into groundwater-based drinking water resources: An appeal to national and local governments, water boards and farmers. Science of The Total Environment. 2020 Jan 10;699.

[338] https://voluntaryinitiative.org.uk/news/2021/better-bentazone-together/

Pesticide metabolites, transformation products and mixtures in European water

As pesticides disperse into the environment, they find their way into plants and soil, from where they can transform into one or more compounds called metabolites. Metabolites present intermediate or end products of the pesticide through metabolism, and the frequency of their detection in groundwater can exceed that of their parent compounds as they can be more polar, less volatile and less biodegradable than their parent compounds resulting in higher mobility. These characteristics also enhance their transfer along surface water – ground water interfaces [339][340]. Moreover, metabolites can be toxic and pose the risk of contaminating drinking water sources, and some metabolites of parent compounds are also approved as active substances. Even if metabolites display no immediate health or environmental risk, the increased presence of pesticides and their metabolites in drinking water can undermine the public's trust in drinking water safety as stated in Kotal et al[341] . Within Europe, the Drinking Water Directive sets general parametric values for the quality of drinking water for pesticides and their metabolites. The gap in available information on metabolites in the environment was further verified in an interview with the JRC. Whereas some tracking of well-known metabolites is undertaken by some MS, there is a lack of information on metabolites, and there are lesser-known metabolites where the effects are unclear.

There are no cases in which only a single substance occurs in the environment. More recently, systematic efforts have demonstrated that mixtures of chemicals affect ecosystem integrity in aquatic ecosystems to the extent that simultaneous exposure to pesticides, along with other forms of stress, can render aquatic organisms up to 100 times more sensitive to pesticides[342]. The EU projects SOLUTIONS and MARS found that on average 20% of aquatic species are lost due to exposure to chemical mixtures, with increasing exposure reducing the integrity of aquatic ecosystems[343] .

Water quality and climate change

As the influence of climate change increases, there will be both positive and negative impacts on agricultural (and forestry) production, which will vary across Europe, particularly where long production cycles and permanent crops are cultivated. Production in cool, wet, upland areas may benefit from warmer and drier conditions, while production in lowland areas may fall. This may change water quality monitoring regimes and lead to change in location of pesticide levels in surface and groundwater. Warmer temperatures will increase the length of growing seasons – requiring more plant protection products. Crops such as autumn-sown cereals, however, may yield less than their potential if they mature earlier. Changing rainfall patterns, increased evaporative demand and reduced availability of water for irrigation all threaten agricultural production, particularly in areas where water supplies are already under pressure. Heavy rainfall events and increased flooding, including that caused by sea-level rise, may lead to substantial pesticide run-off into rivers, losses in crop production in low-lying agricultural areas and may contribute to compaction, waterlogging and erosion of soil. Wetter autumns and winters will threaten agricultural production

[339] Simone Hintze, Gaétan Glauser, and Daniel Hunkeler, "Influence of Surface Water – Groundwater Interactions on the Spatial Distribution of Pesticide Metabolites in Groundwater," *Science of The Total Environment* 733 (September 2020): 139109, https://doi.org/10.1016/j.scitotenv.2020.139109. Hintze, Glauser, and Hunkeler.

[340] Hintze S, Glauser G, Hunkeler D. Influence of surface water–groundwater interactions on the spatial distribution of pesticide metabolites in groundwater. Science of The Total Environment. 2020 Sep 1;733.

[341] Kotal F, Kožíšek F, Jeligová H, Vavrouš A, Mayerová L, Gari DW, Moulisová A. Monitoring of pesticides in drinking water: finding the right balance between under-and over-monitoring–experience from the Czech Republic. Environmental Science: Processes & Impacts. 2021;23(2):311-22.

[342] Posthuma L, Dyer SD, de Zwart D, Kapo K, Holmes CM, Burton Jr GA. Eco-epidemiology of aquatic ecosystems: Separating chemicals from multiple stressors. Science of the Total Environment. 2016 Dec 15;573:1303-19.

[343] Posthuma L, Brack W, van Gils J, Focks A, Müller C, de Zwart D, Birk S. Mixtures of chemicals are important drivers of impacts on ecological status in European surface waters. Environmental Sciences Europe. 2019 Dec;31(1):1-7.

by adversely affecting the timing of land-management operations. This is intertwined with pesticide efficacy, timing and frequency of pesticide applications, as well as alternative management controls for plant protection, determining the environmental receptor (water bodies) for pesticides.

10.1.6.3 *Predicted impacts of the pesticide targets in the Farm-to-Fork Strategy on water quality*

A reduction in 50% of the most hazardous pesticides target in the Farm-to-Fork Strategy would be in addition to the ongoing regulatory programme in the CfS list for pesticides approval. The additionality of the target on EU-wide restrictions of pesticides that are also acutely or chronically toxic to aquatic life (or to human health via contaminated drinking water) – as may be inferred from the pesticide targets in the F2F Strategy - should lead to improvements in surface water and groundwater chemical status from these substances by 2030. However, with relatively few waterbodies currently failing quality standards for pesticides, we may be seeing the results of earlier withdrawals of hazardous pesticides, although that interpretation may be treated with caution (see also chapter 10.1.2) The consequences of additional (future) restrictions (under F2F) may not be observed through monitoring studies for some years. .

In terms of the 50% reduction in pesticide use in the F2F Strategy, Ippolito et al (2015) showed that a determining factor in insecticide run off into streams is insecticide application rate. Using a spatially explicit model for the northern hemisphere, the authors showed insecticide runoff presented a latitudinal gradient mainly driven by insecticide application rate and a global map of hotspots for insecticide contamination, which could inform the implementation of use reduction targets (and in baseline scenario measures).

However, a SWOT analysis of various policy mechanisms that may be used as a proxy for the pesticide targets in F2F Strategy, revealed an overall lack of evidence of the impact on pesticide use when faced with a ban or partial ban on pesticides. The evidence base for the effectiveness of policy mechanisms to reduce the environmental impacts of pesticides is generally low or absent. However, a targeted ban of a problematic pesticide was viewed as a strength for reducing impacts on water quality (also indicated by Underwood & Mole, 2016) and an opportunity for restrictions or promotion of alternatives was viewed in the CfS process, which could be extended to the pesticide targets in F2F Strategy. It was noted by the authors that policy measures to reduce pesticide use alone were only effective when supported by a broad array of other policy instruments to match different farmer motivations[344]. The Underwood & Mole (2016) study states that withdrawals are a relatively simple solution to the problem of water quality infringements, although as shown in the baseline scenario, a relatively small number of active substances cause most of the problems and the additionality of the pesticide targets in Farm-to-Fork may not provide additional value to the aquatic environment.

In theory, a farmer's pest control toolkit would reduce through the non-approval of the 'most hazardous' pesticides in the F2F strategy, farmers would turn to the remaining pesticides approved for use and other means of pest or weed control. A selective herbicide case study reported by Morton et al (2019) serves as a reminder that switching from a PPP/active substance with residual activity to an alternative PPP gave risk to increased adverse effects in the adjacent aquatic environment. In the Morton et al (2019) study alternative weed control measures were suggested such as raising soil pH by liming, land drainage and cutting, and avoiding overgrazing. However, these traditional non-chemical methods may well have unintended consequences for the environment, such as changing the soil pH will change the local vegetation (non-target plants and biodiversity). This case study provides an insight into the pesticide targets in the F2F Strategy,

[344] Pedersen AB, Nielsen HØ, Christensen T, Hasler B. Optimising the effect of policy instruments: a study of farmers' decision rationales and how they match the incentives in Danish pesticide policy. Journal of Environmental Planning and Management. 2012 Oct 1;55(8):1094-110.

particularly around substitution and alternative approaches to pest control in which there are ecosystem services trade-offs.

In conclusion, these studies show that risks to water quality can be reduced through the withdrawal or reduction in use of pesticides, however, it is likely that only a few pesticides may be responsible for the greatest risk, and these are likely to be addressed under the ongoing review programme of active substances under Regulation (EC) No 1107/2009. The additionality of the pesticide targets in the Farm-to-Fork Strategy may have less of an impact when a more targeted reduction of a few substances could achieve the same environmental benefits.

Consequences for groundwater quality

An evaluation of policy changes to groundwater protection from a study in The Netherlands[345] included quantity restriction on pesticide use. For the purposes of this IA, the policy may be used as a proxy for the pesticide reduction target in the Farm-to-Fork Strategy. The authors report that quantity restrictions on pesticide use are expected to reduce farm-level pesticide applications and, as a result, reduce groundwater pollution. However, there are trade-offs, as such a restriction may have a negative effect on farm profitability in high pest infestation years, where increased pesticide use may be required to combat pest damage. For instance, a quantitative restriction on pesticide use would cause a significant decrease in groundwater pollution, but at the same time it would negatively impact long-term farm income. This represents a trade-off. The authors reported with 10, 20, and 30% cuts in pesticide use, farm profit falls by 9 to 12% and groundwater contamination reduced by around 8%, 25% and 34%, respectively. In terms of this IA, these reductions would be in addition to the potential yield and economic consequences of the Candidates for Substitution baseline scenario. National Action Plans targeted at a few key active substances which repeatedly cause issues in groundwater quality through the baseline scenario may have a lower impact on farm profitability than a general quantitative use reduction target.

Water quality conclusions

The main conclusions are summarised below:

- The European Union State of the Environment Report (2020) predicts a "mixed picture" for the water environment in its outlook to 2030;
- Insecticides may be responsible for more than half, and herbicides for more than one-quarter, of acute risks to aquatic life in the EU. Also, only a few pesticides might account for most of the risk to aquatic life;
- Reporting of priority substances under WFD may be under-representative of the most hazardous pesticides currently in use, as it includes pesticides that are already restricted in Europe. Monitoring frequency (typically up to 12 times per year) in small rivers misses the short time in the growing season when a pesticide typically enters surface waters after use. Small waterbodies may not be routinely monitored. Also averaging concentrations over a year means that threshold standards for chronic exposure are not exceeded;
- It is expected that restrictions in use would continue to 2030 through the Candidates for Substitution approach under Regulation 1107/2009 and be influenced by WFD policies. Restrictions and changes in practice prior to 2020 have been enacted on specific active ingredients (e.g. atrazine) and these controls have been effective, however, priority substance pesticides or newly restricted pesticides may persist in aquatic systems to 2030 (and possibly beyond);

[345] Theodoros Skevas (2019): Evaluating alternative policies to reduce pesticide groundwater pollution in Dutch arable farming, Journal of Environmental Planning and Management, DOI: 10.1080/09640568.2019.1606618

- In order to understand and manage risks to water quality, the ecological and landscape contexts must be accounted for in risk assessment, such as, the sensitivity and functions of organisms, habitat type and climate, and site-specific aspects such as the connectivity to nearby populations (for re-colonisation) and presence of additional stressors;
- There are uncertainties around mixture toxicity and the potential for combined effects of pesticides and other chemicals on aquatic systems;
- Professional users may switch to using authorised pesticides containing more water soluble active substances than those which they used previously, but which are no longer available following non-renewal, thereby increasing exposure and risk to aquatic life; and
- Studies have shown that legally binding pesticide targets in the F2F Strategy would reduce risks to water quality through the withdrawal or reduction in use of pesticides, however, it is likely that only a few pesticides may be responsible for the greatest risk, and these are likely to be addressed through existing Candidates for Substitution processes. The pesticide targets in the F2F Strategy may be unnecessary as a smaller overall, but more targeted reduction of certain substances could achieve the same environmental benefits.

10.1.7 Pollination services

Pollination is the transfer of pollen between male and female parts of flowers enabling plant fertilisation and reproduction in crop production and wildflowers. Nearly 90% of the world's flowering plants require animal pollination[346], which is mostly performed by insects such as bees, flies and butterflies, but also includes some birds and bats. Pollinators can travel some distance, even migrate between countries transferring pollen to another, separate population of plants of the same species, enabling cross-pollination, which maintains genetic diversity and species health[347].

10.1.7.1 *Drivers for changes in pollination services*

Pollinators are not just responsible for boosting crop yield and supporting food security: they also enhance crop quality and, in turn, their economic value (see Chapter 10.2.2). Many fruit, vegetable, nut and oil crops are essential to human health, supplying key nutrients for a balanced diet and helping prevent many serious diseases (see Chapter 10.3.4). They also increasingly provide biofuels for alternatives to oil and gas energy. Pollinators and the plants they pollinate form an intimate and intricate web of relationships that helps bind ecosystems together, create healthier plants and build a bedrock for the survival of other species. Pollinator loss will erode valuable ecosystem services for humans, beyond pollination. For instnace, a resultant loss of pollinator-dependent plants will reduce the ability of ecosystems to store carbon and protect against floods, while the loss of certain pollinators themselves can also take away their pest control services. We also stand to lose the social and cultural values that many pollinating species provide to society[348].

Pollinators are important from an economic perspective: in the EU, around 84 % of crops and 78 % of temperate wildflowers depend, at least in part, on animal pollination and an estimated EUR 15 billion of the EU's annual agricultural output is directly attributed to insect pollinators[349]. In

[346] Potts SG, Imperatriz-Fonseca V, Ngo HT, Biesmeijer JC, Breeze TD, Dicks LV, Garibaldi LA, Hill R, Settele J, Vanbergen AJ. The assessment report on pollinators, pollination and food production: summary for policymakers. Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; 2016.

[347] Science for Environment Policy (2020) Pollinators: importance for nature and human well-being, drivers of decline and the need for monitoring. Future Brief 23. Brief produced for the European Commission DG Environment. Bristol: Science Communication Unit, UWE Bristol.

[348] Science for Environment Policy (2020)

[349] EC, 2018, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment (COM(2018) 673 final, Brussels, 11.10.2018).

addition, some pollinators such as bees also provide food and additional income for rural families, in the form of honey and other by-products - thus, declining pollinator populations can impact on the sustainable livelihoods of rural families[350].

There is no single overriding cause of wild pollinator decline, although the main drivers appear to be land-use change, intensive agricultural management and pesticide use, environmental pollution, invasive alien species, pathogens and climate change. Drivers for change are summarised in the table in section 10.1.9 but drivers particular to pollination services include the following:

- Crop type (e.g. self-fertilising) and crop cover
- Timing of pesticide applications (e.g. avoidance of flowering time)
- Land use change, fragmentation and distance to foraging areas and nesting sites
- Disease (e.g. varroa in bees)
- Invasive alien species, especially in island ecosystems; and
- EU Pollinator Initiative.

10.1.7.2 *Estimated changes in pollination services in the Baseline Scenario*

As European biodiversity has been reported to generally be declining (Chapter 10.1.4), pollinators are in sharp decline. The European State of the Environment report reflects the decline in pollination services across Europe and references the global review of 73 reports of insect species declines[351] concluding that habitat loss by conversion to intensive agriculture, followed by urbanisation, pollution (mainly pesticides and fertilisers), invasive alien species and climate change (to the least extent in moderate climatic zones) are the main drivers of decline. For example, a 76% fall in the biomass of flying insects in protected areas in Germany between 1989 and 2016[352]. The study concludes that the underlying drivers of the decline in common species are not changing favourably.

Some studies have shown correlations between intensive agriculture and pollinator species richness, including an influence of higher pesticide loads at regional scales, while at farm scales bumblebees (in arable situations) and butterflies responded positively to organic management[353]. Landscape-scale surveys of wild bees and butterflies in Italy also showed that species richness tends to be lower where pesticide loads, and cumulative exposure risk are high[354]. Such correlative patterns may indicate field impacts of pesticides and herbicides on pollinators and their forage plants. However, these pollinator populations (and other components of biodiversity) are governed by a complex of ecological processes that operate at multiple spatial scales and there are calls for greater realism in risk assessment[355].

Diversity ensures that pollination can occur under a range of conditions, for instance, at night-time, during different weather conditions or if the environment changes significantly. Different animals are also better suited to pollinating different plants. Therefore, this pollinator mix should include

[350] Gallai N, Vaissière B. 2009. Guidelines for the economic valuation of pollination services at a national scale. Rome, FAO

[351] Sánchez-Bayo F, Wyckhuys KA. Worldwide decline of the entomofauna: A review of its drivers. Biological conservation. 2019 Apr 1;232:8-27.

[352] Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, Stenmans W, Müller A, Sumser H, Hörren T, Goulson D. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE12 (10): e0185809.

[353] Gabriel, D., et al., Scale matters: the impact of organic farming on biodiversity at different spatial scales. Ecology Letters, 2010. 13(7): p. 858-869.

[354] Brittain, C.A., et al., Impacts of a pesticide on pollinator species richness at different spatial scales. Basic and Applied Ecology, 2010. 11(2): p. 106-115.

[355] Vanbergen AJ, Heard MS, Breeze T, Potts SG, Hanley N. Status and value of pollinators and pollination services.

rare species to ensure a broad spectrum of pollination services. The full breadth of species diversity in existence is surprising; there are around 2000 bee species in Europe.

Evidence suggests that land-use factors, including the use of pesticides, have had the greatest impact on pollinator numbers and diversity by leading to the loss of food and nesting resources through habitat loss, deterioration and fragmentation. This is especially the case in highly simplified, farmed landscapes. Land-use change and management will continue to be influential in future, but we can also expect climate change to have much more of an impact on pollinator habitats in coming decades[356]. Full implementation of a range of policy measures, including sectoral policies, is required to deliver improvements to 2030 with Europe already failing to halt the loss of biodiversity 2020 targets.

Policy instruments for biodiversity have recently come into play with targets to 2030, and a specific strategy for pollinators was published in 2018 - The EU Pollinators Initiative. This sets strategic objectives and ten actions to 2030 for the EU Member States to reverse the decline of wild pollinators[357]. A review on progress was published in May 2021 following the European Court of Auditors special report on EU actions to protect wild pollinators ('the ECA report') in July 2020. The ECA report recommend that the European Commission assess the need to add specific measures to address threats currently not considered in the Initiative; the need to better integrate actions to protect wild pollinators in the EU biodiversity conservation and agricultural policies; and the need to improve the protection of wild pollinators in the pesticides risk assessment process, including defining specific protection goals for wild pollinators [358].

The review concluded significant progress has been made in the implementation of the Initiative's actions, including schemes to monitor pollinator species, however, it is reported that efforts will need to be stepped up, particularly to address the loss of habitats in farming landscapes and the impacts of pesticides. The Commission cites the EU Biodiversity Strategy, the EU Farm-to-Fork Strategy and the EU Zero Pollution Action Plan as the vehicles to boost actions to reverse the decline of pollinators through commitments and targets for nature protection and the EU nature-restoration plan. These include commitments to expand protected areas and restore ecosystems; promote agro-ecological approaches such as organic agriculture, restoring high-diversity landscape features on farmland and reducing the impacts of pesticides. However, these strategies have no legal mechanism for affecting change. In the second half of 2021, the Commission will launch consultation activities to collect views and more comprehensive evidence, insights and experience from both stakeholders and the general public on the implementation of the existing framework.

Pollinator Initiative Action 7 aims to reduce the impacts of pesticide use on pollinators. In 2018, the Commission discussed with Member States the possibility of integrating specific targets and measures for pollinators into the revised Member State national action plans (NAPs) under the Sustainable Use of Pesticides Directive (action 7A). However, within the review of NAPs published in November 2020, a low level of integration was reported. The Commission's Progress Report stated Member States must make more efforts to strengthen the provisions for pollinating insects in the NAPs.

Specific pollinator guidance is now part of Regulation 1107/2009 risk assessment and authorisation process through the assessment of acute risks to honeybees. A review is currently underway for

[356] (Science for Environmental Policy, 2020).

[357] https://ec.europa.eu/environment/nature/conservation/species/pollinators/policy_en.htm#:~:text=On%201%20June%202018%2C%20the,contribute%20to%20global%20conservation%20efforts.

[358] European Commission (2021). Report from The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions Progress in the implementation of the EU Pollinators Initiative COM/2021/261 final

incorporating chronic toxicity and larval toxicity for honeybees and acute toxicity for bumblebees, although it is noted that there are calls for greater realism in risk assessment from field and monitoring studies. Recent restrictions on the use of some neonicotinoid active substances have garnered strong regulatory and public attention in relation to pollinators. Additional consideration of pollinators in PPP risk assessment should increase pollinator protection through to 2030. There is allowance under Regulation (EC) No 1107/2009 for Member States to grant emergency authorisations for neonicotinoid-PPP not authorised on their territory, for a limited period and a limited and controlled use, where a danger cannot be contained by any other reasonable means. The Commission mandated EFSA in 2018 to verify whether emergency authorisations granted repeatedly on certain crops were justified and took action to prevent unjustified emergency authorisations (for Romania and Lithuania) in 2020. In October 2020, the Commission sent a second mandate to EFSA to assess by September 2021, to determine whether certain emergency authorisations for the use of these substances in sugar beet fulfil the conditions set out in the Regulation. Based on the outcome of this mandate, the Commission may take further action[359], which may influence the 2030 baseline in favour of greater protection for pollinators.

Organic farming outlook

There is considerable variation across Member States in the area of farmland planned to be converted and maintained according to the requirements under the organic farming regulation. It seems unlikely that significant landscape level and population impacts would often occur with the organic coverage levels in most Member States (although farm-level benefits would be expected). One prediction showed that 30% coverage of Agri-Environment-Climate Measure under CAP is required to have population level impacts, then greater coverage would be required for organic farming.

Through the EU Biodiversity and Farm-to-Fork strategies, the Commission committed to take action to halt the loss of biodiversity and is anticipating the Pollinator Initiative will be enacted through these strategies, although the mechanism is unclear. The Pollinator Initiative Action 5: Improve pollinator habitats on and around farmland was reviewed by the Commission in 2019 to assess the potential of the CAP 2014-2020 to conserve wild pollinators. Following a series of reports and consultations the Commission found that several Member States use targeted measures to protect pollinators under the CAP. However, it is evident that such efforts need to be significantly scaled up across the whole EU. For example, Ecological Focus Areas (EFA) under CAP had the potential to provide substantial benefits to pollinators, but according to an expert team from across the EU, current EFA options could be substantially improved for pollinators with appropriate management and adoption of a landscape-scale approach to enhance landscape structure (Cole et al, 2020)[360]. If these landscape measures are enabled through the CAP, there could be an improvement seen in pollinator numbers, however, these may be localised (at farm level).

Following stakeholder discussions in 2020, the integration of pollinator-conservation objectives into the CAP strategic plans 2021-2027 were proposed, including (i) the new 'green architecture' built on enhanced conditionality; (ii) eco-schemes and environmental management commitments and (iii) the obligatory higher environmental ambition. These three factors are said to support the other targets of the EU Biodiversity Strategy for 2030 that are essential to support pollinator-friendly

[359] To further increase transparency, notifications of emergency authorisations by Member States are published in the EU pesticides database.

[360] Cole LJ, Kleijn D, Dicks LV, Stout JC, Potts SG, Albrecht M, Balzan MV, Bartomeus I, Bebeli PJ, Bevk D, Biesmeijer JC. A critical analysis of the potential for EU Common Agricultural Policy measures to support wild pollinators on farmland. Journal of Applied Ecology. 2020 Apr;57(4):681-94.

farming landscapes, such as at least 10% of agricultural area under high-diversity landscape features.

Furthermore, in its recommendations to Member States the Commission also addresses the specific objectives of protecting biodiversity, enhancing ecosystem services, and preserving habitats and landscapes. The ECA report recommended that the Commission verify that Member States include in their strategic plans, whenever necessary, management practices that have a significant and positive effect on wild pollinators. The choice and design of interventions and management practices proposed by Member States should be based on the analysis of their environmental situation. This analysis should lead Member States to identify needs – including pollinator conservation if relevant for a given territory – to be addressed by the strategic plans. The Commission has continued its work to develop a CAP indicator on wild pollinators, but this depends on the implementation of the EU pollinator-monitoring scheme in the Member States[361].

Recommendations on these objectives are expected to help foster the conservation of wild pollinators on farmland. However, the ECA report goes on to note that despite existing provision for semi-natural habitats, the impacts of individual measures are uncertain as biodiversity and pollinator diversity and abundance is in decline. An interesting comparison of Czechia's farmland bird populations before and after accession to the EU and implementation of the CAP demonstrate a decline following accession. Based on this evidence, the authors conclude that 'entering EU's Common Agricultural Policy caused significant deterioration of farmland biodiversity', and also that the greening measures in the Member State were unable to prevent the decline.

Predicted impacts of the pesticide targets in the Farm-to-Fork Strategy on pollination services

A reduction in 50% of the most hazardous pesticides target in the Farm-to-Fork Strategy would be in addition to the ongoing regulatory programme in the Candidates for Substitution list for pesticides approval. The impact on pollination services was the recent regulatory driver to withdraw some neonicotinoid insecticides from multiple crop protection uses. Action was taken within existing regulatory measures and the additionality of the pesticide targets under the Farm-to-Fork Strategy alone are unlikely to benefit pollinators more than, for example, the Pollinator Initiative that would make specific provision for pollinators and their foraging habitats, and the inclusion of pollinator-specific ecotoxicity testing under Regulation 1107/2009.

Pollination services conclusions

- The European State of the Environment report predicts an improving outlook to 2030 for pollination services (an ecosystem service) as a result of the EU Pollinators Initiative (plus green infrastructure investments in urban areas, for example) and recommendations to strengthen the environmental risk assessment of plant protection products for pollinators;
- However, additional actions are needed through the CAP to encourage pollination services in agricultural landscapes. Unless there are similar action to update regulations (such as pollinator-specific tests added to risk assessment under Regulation 1107/2009) or incentives for the implementation of landscape management for biodiversity enhancement and pollinator populations through the CAP, it may be concluded that the agricultural intensification under CAP either diminishes pollination services over the next decade or needs to be compensated through

[361] European Commission. 2021. Environment A. Evaluation of the impact of the CAP on Habitats, Landscapes, Biodiversity. Final Report. 2019 Nov.

pollinator-specific objectives (and incentives) with a landscape perspective – and for substantial areas across Europe; and

- It is unlikely that the additionality of the pesticide targets in the Farm-to-Fork Strategy will influence pollination services without corresponding policies in the CAP and other measures to implement the multiple actions of the Pollinator Initiative.

10.1.8 *Biological pest control*

Biological pest control is the use of living organisms to control pest populations. As with conventional farming, the most effective form of biological pest control requires accurate knowledge of crop and pest biology, ecology, phenology (lifecycle events in response to seasons and climate) and pest-crop interactions. Much of the literature relates to organic farming, but is not exclusive as the assessment of natural pest control overlap with IPM techniques, which includes the use of pesticides, and overlaps with the sections on the environmental indicators for biodiversity and pollination services.

Biological control relies on predation, parasitism and herbivory, or other natural mechanisms with active farmer's management. Biological control of insect pests are predators, parasitoids and pathogens, while weeds are controlled by seed predators, herbivores and plant pathogens. In organic farming, biological agents can be imported to locations where they do not naturally occur, or farmers can make a supplemental release of natural enemies, boosting the naturally occurring population[362].

10.1.8.1 *Drivers for biological pest control*

The SUD, and in particular IPM, encourage strategies for beneficial organisms and is a primary driver for biological pest control. Cultural IPM tools rely on strategies to make the crop unattractive to pests, for example, diverting pest attack away from the crop to ‘trap’ planting. Other methods of control include crop rotation and mixed cropping.

Mechanical and physical IPM controls include tillage, mulching and soil coverage or barriers, such as soil solarisation in southern European countries. However, these can be more harmful to ecosystem services, including beneficial organisms, than selective pesticides[363].

Policy and other drivers for biological pest control are listed in Table 10.1. The drivers that encourage biological diversity and natural or semi-natural habitat adjacent to crops, such as the EU Biodiversity Strategy, should influence biological pest control.

10.1.8.2 *Estimated changes in biological pest control services in the Baseline Scenario*

Crop provision as an ecosystem service was assessed by Maes (2018) by disentangling the yield generated by the ecosystem from what is generated by human inputs such as pesticide inputs. Analyses of changes over time are based on Eurostat statistics for 13 crop types including wheat, maize, potatoes and sugar beet, representing approximately 82% of the extent of all arable land in Europe. Maes (2018) estimated the contribution of ecosystems, such as biological pest control and pollination, to crop provision to be 21% of the total yield. This means that the remaining 79% of yield is derived from human inputs, including pesticides. As Europe moves towards lower input pesticide regimes in plant protection, this ratio must be borne in mind as to whether all agricultural systems and situations can increase its biological pest control to maintain crop yield.

[362] https://blog.agrivi.com/post/best-practices-for-pest-management-in-organic-farm-production

[363] An ecosystem services study of crop protection in tomato production in Italy - Deacon et al, 2016

A similar percentage contribution was determined by Bengtsson (2015)[364] who tested the relative importance of farming system (conventional vs. organic, indicating human inputs, and management), landscape (field shape and landscape heterogeneity), and biological control of aphids by natural enemies (indicating a regulating ecosystem service) for barley yield on 10 fields in central Sweden. Although biological control was related to increased yield, its contribution was relatively small (<20%). The farming system explained most of the magnitude and variation in yield (47% of the variation, of which 34% was unique). Landscape and biological control had the largest shared contribution to variation in yield (14%). Conventional farming management seemed to have a larger effect on yield than biological control. This could be interpreted as indicating that agricultural production should be further intensified to increase yields, but a high dependency on external inputs may not be sustainable, as is shown by the regulatory State of the Environment reports and similar in this IA.

The importance of natural enemies to crop production is highlighted by Janssen and van Rijn (2021). They show that pesticides in agriculture often do not contribute to pest control ***if*** natural enemies of those pests are present. The authors also reviewed other published research and found similar findings. The research focussed on the main agents for control of arthropod crop pests. Although pesticide applications generally result in short-term decreases of pest densities, Janssen & van Rijn (2021) report that densities can subsequently resurge to higher levels than before. Thus, pesticide effects on pest densities beyond a single pest generation may vary, but they have not been reviewed in a systematic manner. Using mathematical predator–prey models, the authors show that pest resurgence is expected when effective natural enemies are present, even when they are less sensitive to pesticides than the pest. Model simulations over multiple pest generations predict that pest resurgence due to pesticide applications will increase average pest densities throughout a growing season when effective natural enemies are present. The model was compared against published data of field experiments that compared effects of chemical control of arthropod plant pests in the presence and absence of natural enemies, and found this largely confirmed the model prediction.

Conversely, a different perspective is taken by the European JRC's in the development of its CAPRI model, which is used to model environmental and climate ambition in the agricultural sector. The model assumes that lower use of pesticide increases the risk (or severity) of pest attacks on crops. The probability of pest attacks is assumed to result in an annual 10% yield loss, on average, rising to 50% in the worst-case scenarios[365]. This was based on the review of the intensity and probability of pest attacks under reduced PPP use in the EU[366]. Although the CAPRI model is yet to predict environmental benefits, it is interesting to note the default position of yield loss based on pest pressure based on a literature review.

Changes in land use, which appears to be increasing in Europe, can adversely affect biological pest control. Spiders, for example, are important predators in agroecosystems, but certain functional types of spiders rely on specific habitats. Among these are aerial web-building spiders, which are particularly dependent on riparian zones and hedgerows as habitat, which when unavailable or removed impair the functioning of the agroecosystems. The size of field is an important consideration for biological pest control (pollination and biodiversity too). Even small 'habitat

[364] Bengtsson JA. Biological control as an ecosystem service: partitioning contributions of nature and human inputs to yield. Ecological Entomology. 2015 Sep;40:45-55.

[365] Barreiro Hurle, J., Bogonos, M., Himics, M., Hristov, J., Perez Dominguez, I., Sahoo, A., Salputra, G., Weiss, F., Baldoni, E. and Elleby, C., Modelling environmental and climate ambition in the agricultural sector with the CAPRI model, EUR 30317 EN, Publications Office of the European Union, Luxembourg, 2021.

[366] Sanchez B, Barreiro-Hurle J, Soto Embodas I, Rodriguez-Cerezo E. The Impact Indicator for Priority Pests (I2P2): a tool for ranking pests according to Regulation (EU) No 2016/2031. EUR29793 EN, Publications Office of the European Union, Luxembourg. 2019 Jul.

islands' within arable croplands can support unique groups of ground-dwelling spiders and carabid beetles that would be absent in large, regular cropland. The type of habitat in these islands, rather than the islands' size, mostly determines the diversity of species. This suggests that maintaining habitat heterogeneity – even in small quantities – is crucial for conserving biodiversity, ecosystem functionality and biological pest control in agricultural lands. Hence, habitat complexity on a local scale is important for maintaining specialist predator populations that are important for pest control[367].

The importance of wildlife refugia for sheltering biological pest controllers is consistent with a study by Colloff et al (2013)[368]. South Australia's citrus orchards with good ground cover (such as perennial grasses and deep litter layer) had large predatory mite populations with no damage from Kelly's citrus thrips. The authors also calculated the value of this ecosystem services to the growers (Aus $ 2600–8500 per hectare per year). The presence of a diverse, abundant fauna of natural enemies was enhanced by good quality ground cover habitat providing effective biological pest control and greater economic resilience in relation to price volatility shocks than those growers who do not benefit from this ecosystem service.

The presence of semi-natural habitats and landscape heterogeneity are key determinants of the delivery of the biological pest control ecosystem service. Rega et al (2018)[369] developed a pan-European, spatially-explicit model to map and assess the landscape potential to sustain biological pest control. The model considers landscape composition in terms of semi-natural habitats types, abundance, spatial configuration and distance from the focal field. It combines recent high-resolution geospatial layers with empirical results from extensive field surveys measuring the specific contribution of different semi-natural habitats to support insects providing biological pest control. The resulting maps show that currently a large proportion of high-productive agricultural areas in Europe has low potential. The maps demonstrate the importance of policies such as the EU Biodiversity Strategy for the maintenance and creation of heterogeneity in agroecosystems, and the importance of field size.

Farmer behaviour towards biological pest control was explored by Zhang et al (2018)[370]. Farmers perceive biological pest control to be a less important contributor to crop production than soil fertility and pollination. Preferences toward managing semi-natural habitats for natural enemies are also relatively low, while insecticides are commonly used among participants in the study. A farmer's decision to promote biological pest control is positively associated with the perceived importance for crop production, however, farmers expressed a relatively low confidence in the pest control efficacies of natural enemies compared with insecticides, especially under high pest damage levels. There are economic influences too - farmers with greater income have more financial flexibility to adopt either pest control method. The environment surrounding a farm may also influence its owner's willingness to promote biological pest control (Zhang et al, 2018).

[367] Benton T, Bieg C, Harwatt H, Wellesley L, Pudasaini R. Food System Impacts on Biodiversity Loss Three Levers for Food System Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House. 2021:2021-02.

[368] Colloff MJ, Lindsay EA, Cook DC. Natural pest control in citrus as an ecosystem service: Integrating ecology, economics and management at the farm scale. Biological control. 2013 Nov 1;67(2):170-7.

[369] Rega C, Bartual AM, Bocci G, Sutter L, Albrecht M, Moonen AC, Jeanneret P, van der Werf W, Pfister SC, Holland JM, Paracchini ML. A pan-European model of landscape potential to support natural pest control services. Ecological Indicators. 2018 Jul 1;90:653-64.

[370] Zhang H, Potts SG, Breeze T, Bailey A. European farmers' incentives to promote natural pest control service in arable fields. Land Use Policy. 2018 Nov 1;78:682-90.

Non-native invasive species

Non-native invasive species that arrive as a result of trade and travel between countries generally arrive without their natural enemies that keep them in check in their native range. In the case of plants almost all the insects, fungal pathogens or nematodes that would normally inflict damage on the plant are lost, giving the plant an unfair advantage over its new neighbours. A biological control is a means of levelling the playing-field by re-introducing some of the specialist natural enemies that exert control on it in its native range, although sometimes the control may realise its own problems if it adapts to new (and native) hosts.

Invasive plant species rapidly colonise and spread in urban areas, along infrastructure corridors, and in the case of Himalayan balsam, along riverbanks leaving them bare and liable to erosion in winter. Examples of invasive plant species include Japanese knotweed (*Fallopia japonica*) and Himalayan balsam (*Impatiens glandulifera*). Herbicides are important control tools in the armoury against non-native invasive species. However, mechanical techniques may be used, such hand pulling, mowing or cutting. Biological pest control may be used, but has some disadvantages, such as a suitable control is not always available for all invasive plants, they aim to control (not eradicate) and may take 10 years or more to achieve successful control.

Biological pest control and climate

The threats to agricultural and forestry production posed by pests and diseases will increase because of the extension of the geographical areas in which they are found, as well as the spread of newly introduced species and an overall rise in how abundant they are. For trees, greater frequency of drought, heat stress and waterlogging are likely to increase damage and deaths resulting from attacks by pests and diseases.

Climate change will affect the range and quality of the ecosystem services that agriculture and forestry not only provide, but also rely on. These also include biological pest control, climate control, flood regulation, biodiversity, pollination and nutrient cycling.

10.1.8.3 *Predicted impacts of the pesticide targets in the Farm-to-Fork Strategy on biological pest control services*

A reduction of 50% in the use of chemical pesticides and a 50% reduction in the most hazardous pesticides targets on the Farm-to-Fork Strategy would be additional to existing pesticide authorisation mechanisms. In theory, a reduction in the range and availability to use chemical pesticides should lead to a greater reliance on biological pest control. There is a potential benefit for this ecosystem service, but the transition will take time and its success will only be dependent upon other land use policies, which will need to go beyond the EU Biodiversity Strategy, to provide and attract habitats for natural enemies for pest control. It is uncertain that the supporting mechanisms for land use change will be in place to 2030 and a cautious “no change” is concluded for this IA.

10.1.9 Summary and conclusions

In summary, the European State of the Environment report is indicating at best “a mixed picture” or a general further deterioration in biodiversity, soil and water quality, pollination and biological pest control services to 2030.

The target of 50% reduction in the most hazardous pesticides in the Farm-to-Fork Strategy is likely to have a marginal impact over and above existing pesticide authorisation mechanisms in Regulation (EC) No 1107/2009 and related legislation, such as the Water Framework Directive, which will manage pesticide hazard over the next decade.

The target of 50% reduction in the use and risk of chemical pesticides in the F2F Strategy is likely to have a greater impact on the environment over the next decade as plant protection management strategies would need to change. This is likely to lead to a greater uptake of IPM strategies, which carry benefits and disbenefits for ecosystem services leading to environmental trade-offs.

The main pressure on agroecosystems is the loss or change in land use, particularly natural or semi-natural habitats, which provide resilience, refuges for recovery and ecosystem services including biological pest control, water and soil quality maintenance, pollination and underpin biodiversity. These could potentially compensate for the influence of pesticide use. Not only do these areas need conservation and management themselves, but they also need to compensate for other pressures in the agroecosystem where this is still maintained as a monoculture. Policies that promote greater heterogeneity and support farm revenues during policy transition and into the future (such as payment for ecosystem services) are needed.

A summary of the direction of change in the environmental indicators is presented below. The baseline is mainly influenced by the 2030 predictions of the European Environment Agency, although a more positive outlook has been taken for pollination services based on the implementation of some of the Pollinator Initiative actions and the assumption that more will follow in the next decade. The outlook for the pesticide-related targets in the Farm-to-Fork Strategy are tempered by the reasons given above and the greater influence of land use.

Specifically, the baseline column in the table presents and informed judgement on the direction of travel of the selected indicators over the 10-year period, based on the evidence base available and presented above. The second column presents an informed judgement on the additionality of SUD to those indicators, in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved. In this context, an upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator. The addition of e.g., a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD revision is expected to reinforce the baseline trends, whereas e.g., an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends.

However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, particular uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results

Table 10-1 Anticipated impacts on the environment

	Baseline	Pesticide related targets in F2F
Effects on the environment		
• Biodiversity and landscapes	↓	↓
• Soil quality	↓	↓
• Water quality	↓	→
• Pollination services		→
• Biological pest control	↓	→

This impact assessment and future impact assessments would benefit from sustainability assessments being part of the regulatory process (either as part of the SUD or PPP Regulation) and for protection of the environment to include the following measures:

- Expand the involvement of interdisciplinary experts in studies and regulatory decisions to improve its robustness and reliability in assessing the impacts on ecosystem services, by capturing a variety of perspectives and opinions and providing a more rounded analysis and more informed policy decisions.
- Extend the Candidates for Substitution process to assess the long-term consequences of adjusting the pest control toolbox. Taking a herbicide as an example, consider the effects on the seed bank build-up, the impacts on soil-related ecosystem services (e.g., soil fertility, erosion, compaction, structure, biota health), the influence of IPM (e.g. crop rotation), as well as the changes over time of in-field and off-field habitats.
- Measure the influence of pesticides and alternative pest or weed management strategies to ensure that compensatory areas/actions for nature conservation on farms are sufficient to meet Europe's total demand for ecological goods and services.
- The European Environment Agency[371] cites three areas of improvement, (i) wider uptake of sustainable management practices based on agroecological principles, organic farming and nature-based solutions; (ii) implementation and integration of EU policies in the upcoming strategic plans of the EU CAP 2021-2027; and (iii) more holistic approaches to facilitate the transition to sustainable agriculture. Achieving the reductions needed to reach environmental targets requires a combined approach, changing both agricultural practices and consumer demands, which is supported by a transition in food and energy systems.
- Many researchers and food and agricultural organisations agree that reductions in pesticide usage/most hazardous pesticides alone will not be sufficient to address the climate and biodiversity crises, yet as a major European land user/owner, the agricultural sector has substantial opportunities to mitigate both crises. A paper by Chatham House[372] succinctly summarises the redesigning of food systems to restore biodiversity requires three 'levers' for reducing pressures on land and creating a more sustainable food system. The first is to change dietary patterns to reduce food demand and encourage more plant-based diets. The second is to protect and set aside land for nature, whether through re-establishing native ecosystems on spared farmland or integrating pockets of natural habitat into farmland. The third is to shift to more sustainable farming. All three levers will be needed for food system redesign to succeed.

[371] https://www.agroecology-europe.org/new-report-of-the-european-environment-agency-eea-published-on-water-and-agriculture-towards-sustainable-solutions/

[372] Benton T, Bieg C, Harwatt H, Wellesley L, Pudasaini R. Food System Impacts on Biodiversity Loss Three Levers for Food System Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House. 2021:2021-02.

10.2 Economic impacts

- Economic indicators were selected to measure and value potential material economic impacts across the PPP and food value chains. To structure the discussion, the anticipated evolution of the selected economic indicators is analysed around the four categories listed below, however the connections and feedback loops across them are acknowledged and explicit cross references are made as appropriate Impacts on farm productivity and profitability;
- Impacts on PPP and PPP application value chain;
- Impacts on Food Value Chain; and
- Trade Impacts.

For each economic indicator, we have explored the anticipated change brought through reaching the two Farm to Fork related policy targets. To support this process, a large body of literature has been identified and structured which has fed into the assessment.

10.2.1 Overview of main drivers

As outlined in previous sections, the agri-food sector will undergo a transition irrespective of whether the proposed policy changes to the SUD materialise. Pressures and changes on both, the food supply and food demand sides, will arise from a mix of strategies and policies, including but not limited to the F2F and BDS, CAP reform and the Green Deal. In addition, there are wider environmental, demographic, technological and economic factors influencing EU agri-food production, the evolution of the PPP and agri-food value changes and non-EU trade on agricultural goods.

Key drivers influencing the evolution of the baseline over the period 2020 to 2030 are identified in Section 5.1.1 below and further elaborated in the following subsections. The influence of key drivers on particular actors or value chains are highlighted in the discussion as relevant, however this assessment does not attempt to quantify the particular influence of individual drivers across those stakeholder groups, not least given the complexity of the interconnections and the non-linear feedback loops across them. This complexity, together with outstanding research and innovation gaps to identify fully integrated and viable (technically and economically) solutions that reduce the need for pesticide inputs, has limited the availability of reliable scientific prediction in the literature. These limitations and the resulting gaps in evidence base have shaped the approach of the assessment presented in the following sections.

Table 10-2. Overview of key drivers influencing the evolution of the baseline

	Drivers	Influence
Environmental variability and natural resources	• Crop and animal diseases • Pests • Natural climate-related hazards (drought, extreme temperate and rainfall, floods, wildfires) • Weather systems (e.g. trans-Pacific El Niño/Southern Oscillation - ENSO) • Presence and distribution of natural enemies • Habitat loss and decline in biodiversity • Soil quality • Resource scarcity and competition for access	Greater environmental variability and ecological constraints will increase variability and shock events, influencing yields, food loss and prices.
Demographic developments	• Size of world population and ageing EU population • Generational shift of farmers and consumers • Migration • Urbanisation • Dietary shifts	Growing population will increase global competition for food; dietary and cultural influence on food production and trade
Economic influence	• Competition for land/land use changes	Changes in land use/crop reallocation, farm size,

	Drivers	Influence
	• Economic growth and globalisation (e.g. trade, rise of emerging economies, developments in agricultural markets) • Structure of the agro-food sector (power distribution competition, price transmission, etc) • Evolution of the farming sector to face environmental challenges, policy changes and consumption models	productive farm orientation and business structure; new trade agreements, development and uptake of new technologies across the entire agri-food value chain
Science and Technological influence	• Biotechnology (new breeding technologies; synthetic biology; alternative protein sources; food design; bioenocomy) • Digitalisation (precision agriculture – internet o Things; automation & robots; connectivity; virtual services and servitisation) • Technological development • Efficiency improvements • Availability of low-cost PPP alternatives	Technological progress (together with the economic viability of new technologies) will improve resource efficiency and productivity and will drive competition, structure, employment and profitability of farming sector and PPP value chain
Policy influence	• EU climate targets/carbon farming in the EU • International climate agreements • Just transition • Farm incomes - Value distribution in food chain - Food security, nutrition and public health - Food affordability and supply sector competitiveness • Increased area of organic farming • Organic action plan • Food waste • Circular bio-economy and agricultural loss reduction • No net biodiversity loss target • CAP reform • Legislative framework for sustainable food systems • Dietary shifts (i.e. a reduction in calory content and animal products)	Climate mitigation and adaptation, reduction in/avoidance of biodiversity loss, reduced environmental impact from food production along with demand side measure to increase circularity, minimise waste and reduce the demand for the most unsustainable food products. Degree to which these aspects will be incorporated into trade agreements to reduce leakage remains unclear.

10.2.2 *Impacts on farm productivity and profitability*

10.2.2.1 *Estimation of the 2020 – 2030 baseline*

The dynamic baseline was based on by the 2020-2030 EU Agricultural Market Outlook (EC, 2020[373]) commissioned by DG AGRI[374]. Since the potential impacts of the F2F and BDS strategies on food production within the EU are not incorporated in the EC (2020) analysis, the baseline was further informed by the Guyomard, Bureau et al. (2020[375]) policy review of the impacts of the Green deal

[373] EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels. Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2020-report_en.pdf

[374] Projections from this outlook report are based on the OECD-FAO Agricultural Outlook 2020-2029, updated with recent global macroeconomic and market data. While the OECD-FAO Agricultural Outlook published in 2021 presents a more recent outlook for the baseline period, and has been used to inform the analysis as relevant, this update has not yet been incorporated into the EU Agricultural Market Outlook. These statistics have been added for context without further modification.

[375] Guyomard, H., Bureau J.-C. et al. (2020), Research for AGRI Committee – The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU's natural resources. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

and the CAP and the Barreiro-Hurle, et al., (2021)[376] modelling of environmental and climate ambition in the agricultural sector with the CAPRI model, along with three impact assessments (see USDA (2020)[377] ; COCERAL-PUNISTOCK (2021)[378] and the Impact Assessment Study on EC 2030 Green Deal Targets for Sustainable Food Production currently being conducted by Wageningen University and Research on behalf of CropLife Europe). An overview of these studies is provided further below in this section.

Changes in area and production from the 2020-2030 EU Agricultural Outlook

The main relevant findings of the 2020-2030 EU Agricultural Market Outlook (EC, 2020)[379] on the agricultural outlook until 2030 are presented below:

- Cereals[380]: According to the market outlook report, the area under cereals (main crops are wheat, barley and maize) will remain somewhat stable (with a slight decrease from 52.4 million ha (2020) to 51.0 million[381] ha in 2030) while the yields are expected to slightly increase (following past trends) thanks to improved research and innovation, as well as enhanced farming practices and crop management. Due to the increasing yields, cereal production is expected to remain stable.
- Protein crops[382]: The outlook report estimates that the area used by those crops will increase significantly[383] (by 37%) to 2.9 million ha by 2030 and that also yields will increase, leading together to an increase in production, driven by (among others) increasing domestic consumption and popularity for human consumption.
- Oilseeds[384]: The oilseed area is projected to slightly decline towards 2030 period to 10.7 million ha; however, due to increased yields the overall production is expected to increase by 2030 compared to 2020 levels.
- Sugar beet: The area under sugar beet is expected to remain largely stable but that slow growth of yields is expected to lead to an overall small increase in sugar beet production by 2030 compared to 2020.

Three specialised crops are included in the outlook report: olive oil, wine, and fruit and vegetables. In contrast to commodities, these sectors are not included in the modelling, and projections are largely based on expert judgement and literature reviews, taking into account historical trends in supply and demand. The outlook report foresees a growing demand for and production of olive oil (largely by intensification), an increased production of apples, oranges and tomatoes to meet

[376] Barreiro-Hurle, J., Bogonos, M., Himics, M., Hristov, J., Pérez-Domiguez, I., Sahoo, A., Salputra, G., Weiss, F., Baldoni, E., Elleby, C. Modelling environmental and climate ambition in the agricultural sector with the CAPRI model. Exploring the potential effects of selected Farm to Fork and Biodiversity strategies targets in the framework of the 2030 Climate targets and the post 2020 Common Agricultural Policy, EUR 30317 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-20889-1, doi:10.2760/98160, JRC121368.

[377] Beckman, Jayson, Maros Ivanic, Jeremy L. Jelliffe, Felix G. Baquedano, and Sara G. Scott. November 2020. Economic and Food Security Impacts of Agricultural Input Reduction Under the European Union Green Deal's Farm to Fork and Biodiversity Strategies, EB-30, U.S. Department of Agriculture, Economic Research Service.

[378] COCERAL-UNISTOCK, 2021. Impact of the Farm to Fork targets on the Cereals and Oilseeds markets. COCERA-UNISTOCK's main findings.

[379] Information is also provided in the report on other crops (e.g. wine, olives, apples tomatoes); however, those are based on different methodologies and provide less detail and are thus not included here.

[380] Incl. Common wheat, durum wheat, barley, maize, rye, other cereals

[381] Within this category there are different trends, however. For example, concerning maize, the total area is expected to expand across the EU to meet the increasing feed and industry demand.

[382] Protein crops include peas and fava beans as well as lentils, chickpeas and other dry pulses

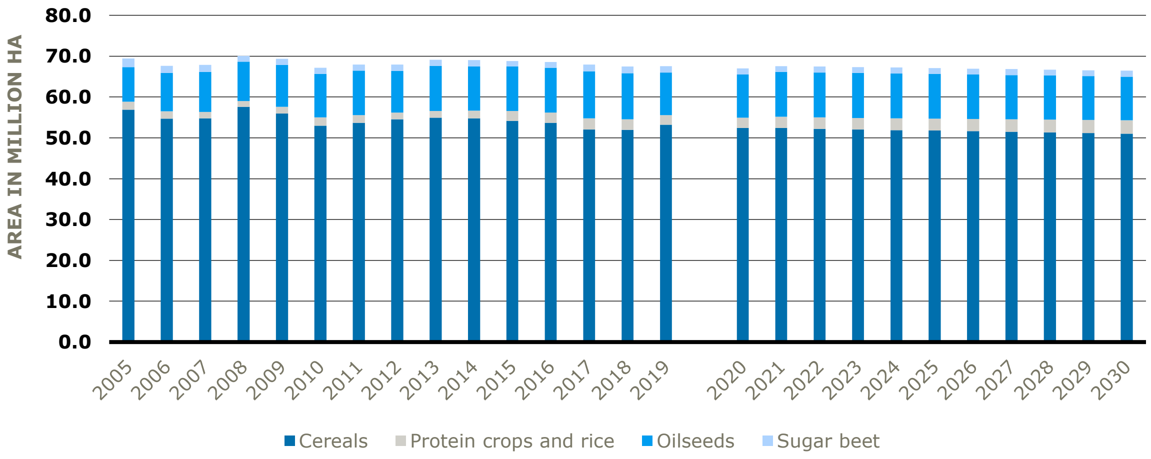
[383] The increase is predominantly driven by protein crops while rice remains stable

[384] Including soya beans, rapeseed and sunflower

growing demand, mainly through yield increases and a stable production of nectarines and peaches. Finally, it is expected that the decline in area under wine production will reverse, leading to a small increase in area with vineyards, mainly for low yield, high quality production.

The graph below summarises the cumulate area under the abovementioned crop types. Date is shown from the earliest available dates (2005) to provide context to the expected developments.

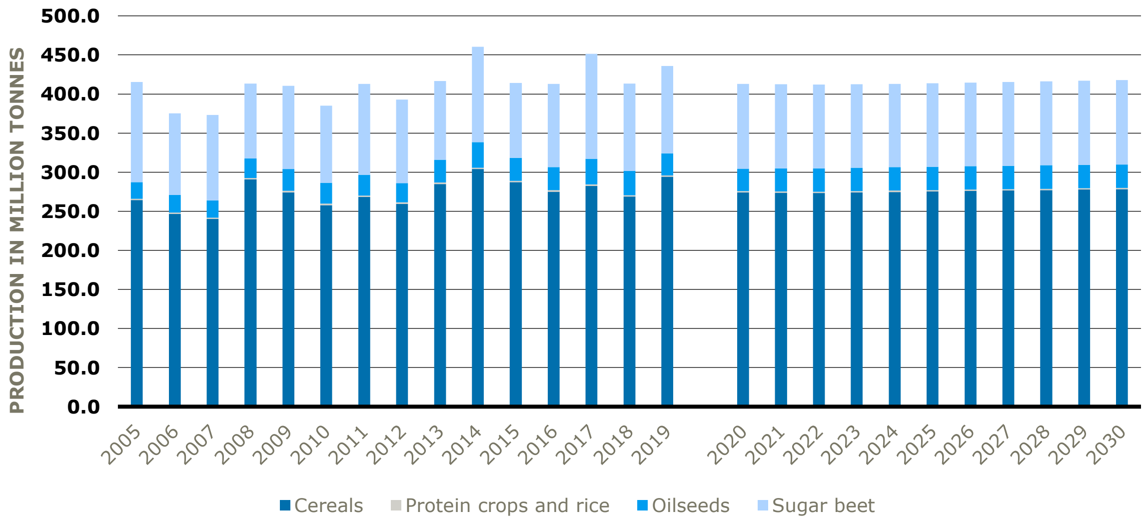
Figure 10.3 Cumulate area under main crop categories between 2005 and 2030



Source: Own illustration based on data from EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels

The following graph shows the corresponding production of those crop types for the same timeline.

Figure 10.4 Production under main crop categories between 2005 and 2030



Source: Own illustration based on data from EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels

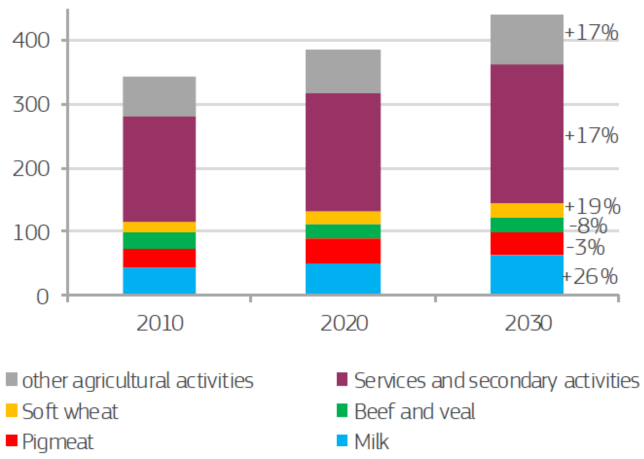
It should be mentioned that for oilseeds as well as sugar the market outlook specifically mentions that important active substances/pesticides will likely not be approved or authorised but that it is expected that the sectors will overcome the challenges and increase yields nevertheless, an argument frequently contested by industry stakeholders and producer representatives.

Changes in farm income from the 2020-2030 EU Agricultural Outlook

The 2020-2030 EU Agricultural Market Outlook[385] also provides a projection on farm income which is summarised below.

The total value of crop production is expected to increase in the 2020-2030 period, in nominal terms by 21%. In the outlook period, the nominal total agricultural output is due to increase by 14%, reaching EUR 440 billion in 2030. This is driven by both prices and produced quantities. Dairy, wheat and oilseeds markets are projected to continue growing, whereas pig meat and beef production should decline while also becoming more sustainable. Services and secondary activities are expected to remain a significant driver of the growth in production. This shown in the graph below from the market outlook report.

Figure 10.5 EU value of farm production (billion EUR) and change 2010 – 2030 in %



Source: EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels

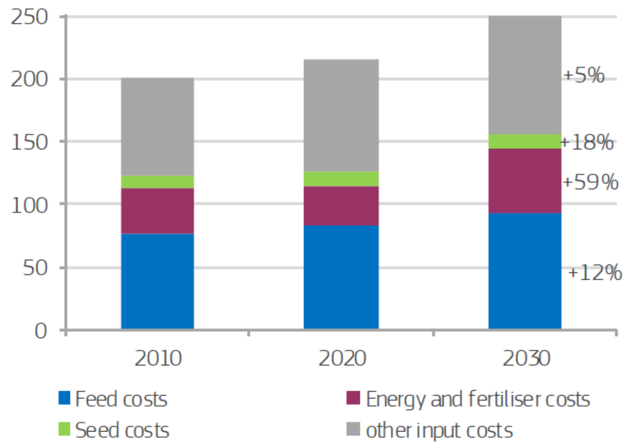
During the same period, the intermediate costs are expected to increase as well, driven by increases in costs of all relevant categories, incl. feed costs, seed costs, energy and fertiliser costs, and other agricultural input costs. Under the "other" category also fall pesticides whose expected development is described as follows in the report[386]: "Use of improved plant protection products could continue increasing in the outlook period thanks to continuous investments in research and development to meet productivity gains and environmental standards. However, their use is expected to slow down, thanks to better targeting and improved management through digital technologies."

The corresponding figure from the report is presented below.

[385] EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels. Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2020-report_en.pdf

[386] It should be reminded that the F2F strategy is not factored into the baseline presented in the report.

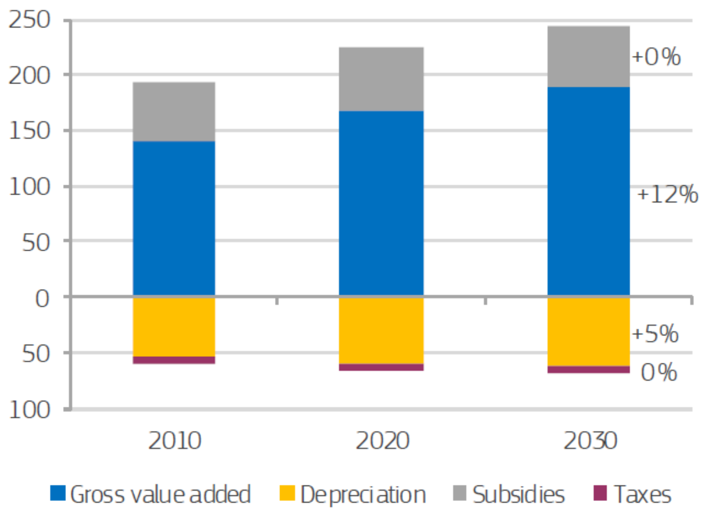
Figure 10.6 EU intermediate costs of farm production (billion EUR) and change 2020-2030 (%)



Source: EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels

Finally, based on the above and other income and expense categories, the market outlook report predicts that the nominal agricultural income is expected to increase in the outlook period at 11% in 2020-2030. This is summarised in the figure below from the report. The gross value added is obtained by subtracting the input costs from the value of production. The agricultural income is then calculated by subtracting the depreciation and the taxes and by adding the subsidies.

Figure 10.7 EU composition of farm income (billion EUR) and change 2020-2030 (%)



Source: EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels

Review of other relevant Impact Assessments and policy analyses of the new regulatory landscape

Five relevant model studies are available to inform the discussion and the results are presented below. Whilst none of the studies reviewed are conclusive, they nevertheless provide relevant insights on how food production may evolve if the F2F targets are met.

The analysis of the policy implications from the Green Deal and the CAP conducted by Guyomard, Bureau et al. (2020)[387] provides a rough economic estimate of the possible impacts of their recommendations for the future of CAP on farm incomes. The aim of the study is to outline the main economic points that should be addressed through a future impact assessment considering all the sustainability dimensions and is not intended as a forecast. The report outlines the challenges and limitations of modelling approaches to fully capture all the dimensions of the policy mix and the difficulty in quantification due to the "complex and imbricated mechanisms at different scales (from the plot to the landscape)". Simulation results show a gain for conventional farms converting to organic production as their income despite the loss in yield based on the assumption that price premiums and CAP payments are maintained at the current level. It is because those CAP payments are greater for organic than conventional farms that the income of farms that convert to organic farming increases, requiring an increase or redistribution in the CAP budget.

Conventional farms would see a 25% decrease in income as average, under central assumptions, and considering that input and output prices as well as CAP subsidies remain constant. The projected reduction in fertilizer and pesticide costs would not be enough to compensate the assumed decrease in production. Thus, the product price increases required to compensate the drop in farm income of conventional farms would range from +4.6% for farms specialised in cereals, oilseed and protein and around +11% for livestock farms. Whilst those prices are not out of reach, there is high uncertainty around the assumptions and values underpinning these outputs. In addition, the impact of price increases on farm incomes may be offset by larger imports, and thus the study argues for a carbon and biodiversity border adjustment mechanisms for climatic and economic standpoints.

The US Economic Research Service of the US Department for Agriculture (USDA)[388] performed a range of policy simulations on various EU targets using three progressively broader adoption scenarios of the EC's F2F and BDS (adoption by the EU only; adoption by some countries, with explicitly EU trade restrictions against non-adopting countries; and global adoption). The analysis of the adoption by the EU only scenario concludes that reaching all proposed F2F targets could lead to a reduction in EU agricultural food production by 12 % across all commodities. Important limitations of the USDA study exist however, and are explored in an analysis by INRA experts[389]. Highlighted limitations include:

- Only a selection of the proposed policies included in the F2F and BDS are modelled (and only in relation to the supply side);
- Certain current trends are not considered, for example the reduction of food waste and agricultural losses and recent changes in Western food diets (i.e. a reduction in calory content and animal products);
- Nor does the study account for adaptation of agricultural practices, cropping or livestock systems that may reduce the need for inputs to agricultural production, or technical progress over the next decade.
- Finally, the rigid framework within which the input restrictions in non-EU countries are interpreted and the agricultural systems are simulated are also highlighted.

[387] Guyomard, H., Bureau J.-C. et al. (2020), Research for AGRI Committee – The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU's natural resources. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

[388] Beckman, Jayson, Maros Ivanic, Jeremy L. Jelliffe, Felix G. Baquedano, and Sara G. Scott. November 2020. Economic and Food Security Impacts of Agricultural Input Reduction Under the European Union Green Deal's Farm to Fork and Biodiversity Strategies, EB-30, U.S. Department of Agriculture, Economic Research Service.

[389] Richard et al., 2020 (unpublished). Findings and limitations of the USDA-ERS study, Economic and Food Security Impacts of Agricultural Input Reduction under the European Union Green Deal's Farm to Fork and Biodiversity Strategies. Available at: https://www.inrae.fr/sites/default/files/pdf/Article%20sur%20rapport%20USDA-ERS-GB_AT_14122020_cy.pdf

A study recently published by the JRC[390] involves the analysis of the potential effects of selected F2F and BDS strategy targets in the framework of the 2030 Climate targes and the post 2020 Common Agricultural Policy. The study presents results (incl. on production of selected crop groups) in two scenarios; one, in which the F2F and BDS strategies' targets are reached without changing the CAP; and one presenting the combined effects of the F2F and BDS strategies targets with a CAP reflecting an ambitious implementation of the legal proposal. Results indicate a decline in EU production and variations in prices and income for selected agricultural products, leading to a decrease in net export positions for cereals and worsening in EU trade deficit for oilseeds, and fruits and vegetables. Producer prices also show an increase in all scenarios, however overall revenues show a decrease due to higher costs. Overall, the results show that the agricultural sector can meet the selected F2F and BDS targets, but it suggests trade-offs in terms of production levels and leakage of GHG emissions and highlights the need for effective instruments to support the sector during the transition, including:

- the need for global action to avoid leakage of pollution to other world areas, as shown by the high levels of leakage for GHG emissions;
- the need for productivity gains with respect to organic farming and nutrient management which can be achieved with precision farming, new digital technologies and other innovative techniques; and
- the significant price impacts indicate the crucial role of changes in consumer behaviour in order to reduce the environmental footprint of food consumption.

However, the report recognises the limitations of its model.[391] Like the USDA-ERS model, the JRC analysis does not fully capture the underlying drivers of the policy initiatives assessed, including some demand side policies like the reduction of food waste, changes in diets or promotion of organic and sustainably produced food. Additional modelling tools are suggested in the JRC report to capture co-benefits of sustainable agricultural production on the environment (including the beneficial impacts of increased biodiversity on crop yield) and human health. Finally, the baseline used in the JRC report does not guarantee that existing EU and national legislation are fully implemented; these are met only insofar they are met by the projections of the Commission's Mid-term outlook (EC, 2020) to which it is calibrated.

COCERAL-PUNISTOCK (2021)[392] published a study on the Impact of the Farm to Fork targets (i) 10% of high diversity landscape area; ii) 25% of organic farming; iii) 50% reduction on pesticide use and risk; iv) 20% reduction in fertiliser use and 50% reduction of nutrient losses) on the cereals and oilseeds market. The study, a quantitative analysis informed by a literature review, expert consultation and professional judgement, projects a decrease in all the crops considered[393] under four scenarios with varying degrees of impact (ranging from low to extreme depending on the assumptions made on the ratio of arable crops impacted relative to the total agricultural area). These impacts compared against a baseline informed by the EU Agricultural Outlook for Markets,

[390] Barreiro-Hurle, J., Bogonos, M., Himics, M., Hristov, J., Pérez-Domiguez, I., Sahoo, A., Salputra, G., Weiss, F., Baldoni, E., Elleby, C. Modelling environmental and climate ambition in the agricultural sector with the CAPRI model. Exploring the potential effects of selected Farm to Fork and Biodiversity strategies targets in the framework of the 2030 Climate targets and the post 2020 Common Agricultural Policy, EUR 30317 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-20889-1, doi:10.2760/98160, JRC121368.

[391] Additional limitations include lack of data (e.g. regional pesticide use by pesticide category) and lack of model specificities (e.g. no distinction between organic and conventional farming), non-comprehensive representation of emission mitigation technologies and farm practices, and failure to capture the full scope of the transition to sustainable food systems (e.g. changes in the value chain, impacts on soil degradation.

[392] COCERAL-UNISTOCK, 2021. Impact of the Farm to Fork targets on the Cereals and Oilseeds markets. COCERA-UNISTOCK's main findings.

[393] I.e. wheat, corn, barley, other grains, soyabean, rapeseed and sunflower seed

Income and Environment 2020-2030[394] but which does not consider legislative proposals not finalised and implemented such as the CAP reform. It should be noted that this study looks at the combined impacts of the aforementioned F2F targets and does not consider the impacts of achieving the pesticide reduction targets in isolation. Production losses vary by scenario and crop, ranging between 8% and 38% for all crops (i.e. wheat, corn, barley, other grains, rapeseed and sunflower seed) under all scenarios, with the exception of soyabean. The study only covers a limited number of crops (wheat, corn, barley, other grains and oilseeds - rapeseed, soy and sunflower seed). In addition, it relies on assumptions in relation to the impacts of the F2F strategies on arable crops (both, in terms of area impacted and yield loss), and does not consider mitigation measures such as IPM, new plant breeding techniques or demand side measures. In this sense, this study seems to constitute a scenario analysis rather than a forecast.

A fourth report is the Impact Assessment Study on EC 2030 Green Deal Targets for Sustainable Food Production currently being conducted by Wageningen University and Research on behalf of CropLife Europe. Even though the study will only be published after completion of this study and will not be available for this assessment, a high-level draft summary of the Impact Assessment was available for review which included preliminary simulation results for some scenarios. However, no detailed information was available on the methodology followed. Whilst the results are partial and preliminary (and in particular it is not clear to what extent demand side considerations have been taken into account), the CropLife Europe analysis also points at likely impacts on the EU trade balance as result of reduced yields, and losses in production due to yield and quality losses which may be partly counteracted by increase in prices driven by resource 'scarcity'.

Finally, a fifth report was published in September 2021[395] which, similar to the JRC study[396], uses the CAPRI model to simulate potential economic and environmental impacts stemming from an implementation of relevant F2F targets (including, among others, the two pesticide related targets). The study builds several scenarios, representing different parts of the F2F strategy that are then compared against a baseline. One scenario covers the two pesticide related F2F targets, which is represented in the model by assuming that farm output is reduced by 10%; an increase of other costs by 50%; and an increase of catch crops by 25 %. Besides the scenarios looking at different parts of the F2F strategy, the study also contains a combined scenario which simulates the cumulative effects of reaching all assessed targets. The limitations of the modelling exercise are similar to those mentioned above for the JRC study. In addition, this study highlights that one of its largest limitations is the fact that the effect of pesticides on biodiversity is not reflected in the model.

The table below summarises the results (where available) from the different modelling exercises in more detail for the main groups of crops mentioned above. However, these projections should be treated with caution in view of the aforementioned limitations.

[394] EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels. Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2020-report_en.pdf

[395] Henning, C., Witzke, P., Pankin, L., Grunenberg, M. (2021), Ökonomische und Ökologische Auswirkungen des Green Deals in der Agrarwirtschaft. Eine Simulationstudie der Eekte der F2F-Strategie auf Produktion, Handel, Einkommen und Umwelt mit dem CAPRIModell. Available at: https://www.bio-pop.agrarpol.uni-kiel.de/de/f2f-studie

[396] See footnote 390

Figure 10.8 Overview of different predictions on area and production for conventional farms

Crop category	Indicator	EU 2020-2030 Outlook	Guyomard, Bureau et al.[397][398]	USDA [399]	JRC[400]	COCERAL-PUNISTOCK[401]	Wageningen	Henning, C. et al[402]
Cereals	Area	Somewhat stable	Decrease	[Only available for all cropland combined with a change of -10.5%]	Decrease by -4% (no CAP changes) Decrease by -7% (CAP changes[403])	[Not available]	[Not available]	[Not available]
	Production	Stable	Decrease	Change of production of -48.5% of wheat and -20% for coarse grains	Decrease by 15% (no CAP change) Decrease by -13% (CAP changes)	Change of production between -8% and -35% of wheat Change of production between -8% and -33% of maize Change of production between -9% and -38% of barley Change of production between -8% and -34% of other grains	[Not available]	Reduction in yield of -10%
Protein crops and rice	Area	Significant increase	Decrease	[Only available for all cropland combined with a change of -10.5%]	[Not available]	[Not available]	[Not available]	[Not available]

[397] Guyomard, H., Bureau J.-C. et al. (2020), Research for AGRI Committee – The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU's natural resources. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

[398] This paper projects changes assuming constant prices of products with a view to estimate price elasticity requirements to maintain the gross margin of farms, and should not be considered a forecast. [398]

[399] EU only scenario

[400] Results given for both scenarios: scenario, in which the F2F and BDS strategies' targets are reached without changing the CAP (no CAP); and one presenting the combined effects of the F2F and BDS strategies targets with a CAP reflecting an ambitious implementation of the legal proposal (CAP)

[401] Results are given as a range between the lowest scenario (low) and highest scenario (extreme impact).

[402] Results given at EU level for the scenario looking at the effects of reaching the two pesticide related targets

[403] As part of the CAP, a 30% cost reduction is assumed for technologies that require significant investment for their adoption

Crop category	Indicator	EU 2020-2030 Outlook	Guyomard, Bureau et al.[397][398]	USDA [399]	JRC[400]	COCERAL-PUNISTOCK[401]	Wageningen	Henning, C. et al[402]
	Production	Increase	Decrease	Change of production of -13.2% of rice	[Not available]	[Not available]	[Not available]	[Not available]
Oilseeds	Area	Some decrease	[Not available]	[Only available for all cropland combined with a change of -10.5%]	Decrease by -4% (no CAP changes) Decrease by approx. -5% (CAP changes)	Change of production between -10% and -36% of oilseeds	[Not available]	[Not available]
	Production	Increase	[Not available]	Change of production of -60.7% of oilseeds	Decrease by -15% (no CAP changes) Decrease by 12% (CAP changes)	[Not available]	[Not available]	Reduction in yield of -10%
Sugar beet	Area	Some decrease	[Not available]	[Only available for all cropland combined with a change of -10.5%]	[Not available]		[Not available]	[Not available]
	Production	Some increase	[Not available]	Change of production of -20.5% of sugar crops (incl. sugar beet and sugar cane)	[Not available]		[Not available]	Reduction in yield of -11%

Climate change considerations

The impacts of climate change expected over the baseline period and the coming decades include increasing droughts, floods, storms and other extreme weather events, all of which pose a risk to European agricultural yields and farm productivity. Notable anticipated impacts recognised by a 2020 JRC Technical Report include declines in EU grain maize yields by 1%-22% and wheat yield declines of up to 49% in Southern Europe, primarily due to water scarcity[404] when only simplified adaptation options are considered. Climate change also brings implications for crop pests. A recent review by the FAO and International Plant Protection Convention (IPPC) acknowledged that the current global climate and increased globalisation of the agricultural market has created a situation extremely favourable to crop pest movement and establishment, a situation expected to worsen as warmer winters in particular facilitate the introduction of unwanted organisms[405].

Adaptation measures detailed in the EU's Farm to Fork and Biodiversity Strategies (e.g. changing varieties and crop types, increasing resilience of agricultural systems through ecosystem service utilisation, and increasing and improving irrigation practices for certain crops), alongside warming climates in Northern Europe are expected to offset some of the negative impacts of climate change and maintain EU food security. However, cascading impacts in other areas of the world are expected to affect the distribution of global agricultural markets and supply chains, bringing agricultural income and food price implications to the EU[406], (these aspects are further discussed in sections 10.2.4 and 10.2.5). Some of these impacts might even bring benefits to EU producers through e.g., increased demand for exports as other global regions struggle to maintain production. However, the impacts of climate change on overall changes in European farm income are as yet unclear, and many limiting factors such as: the increasing water shortage in Southern Europe; irrigation expansion constraints; increasing frequency and severity of heatwaves and droughts; and, importantly, the consequences of reduction of nutrient use due to environmental and climate mitigation constraints, all require further study.

10.2.2.2 *Estimated impacts from achieving the pesticide-related targets announced in the F2F strategy*

Changes in area and production

The question of whether achieving the pesticide-related targets announced in the F2F strategy may lead to changes in agricultural area, yield and production in addition to those already driven by the wider policy landscape is crucial to assessing its further impacts. Estimating that "additionality" is challenging given the complex synergistic effect between the various targets, and there is no conclusive evidence available on the question. The following section summarises available evidence from different sources which informs the scenario in which the pesticide-related targets announce in the F2F strategy are achieved.

[404] Hristov, J., Toreti, A., Pérez, I., Domínguez, F. D., Fellmann, T., Elleby, C., ... and Bratu, M. (2020). Analysis of climate change impacts on EU agriculture by 2050. *Publications Office of the European Union, Luxembourg, doi*, *10*, 121115.

[405] IPPC Secretariat**.** (2021). *Scientific review of the impact of climate change on plant pests – A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems.* Rome. FAO on behalf of the IPPC Secretariat.

https://doi.org/10.4060/cb4769en

[406] Porfirio, L.L., Newth, D., Finnigan, J.J. and Cai, Y., 2018. Economic shifts in agricultural production and trade due to climate change. *Palgrave Communications*, *4*(1), pp.1-9.

Information gathered through stakeholder engagement: Focus Groups

The question of whether reaching the two pesticide related F2F targets would have an impact on production was discussed as part of all focus groups. Opinions varied widely in all focus groups, between "likely there will be a large change" and "likely there will be no change" with a general agreement that this question depends on too many variables to allow for predictions.

However, a common view was that the oilseed and the sugar beet sector would be more impacted. It was also mentioned that horticulture may have more difficulties in switching to alternatives/less alternatives available. In general, the view was that most sectors will be impacted and the economic impacts for producers uncertain or negative, with benefits accruing mainly to consumers and society as a whole and the environment.

Available literature on pesticide dependence

A large catalogue of scientific and grey[407] literature is available on the question if reduction of pesticide use leads to reduction of production (and, subsequently, if this would have implications on the land area used for production). A selection of relevant studies are summarized here.

A recent in-depth analysis study of the European Parliamentary Research Service[408] assessed the available literature and came to the following main conclusions regarding production and area:

- Crop production in the EU without chemical pesticides is not realistic at the moment, but there are indications that reductions are possible without or with economically acceptable yield losses; the (financial) risk for the grower is an important aspect to consider. The question remains, however, of whether a reduction in PPP use without negative effects on yields is achievable in all crops and in all circumstances as inconsistent results are shown in the literature.
- Potential crop losses (i.e. total crop loss without any crop protection) and actual crop losses (i.e. those occurring when plan protection was conducted though PPP and/or by other cultivation measures) are dependent on crop, geography, and wider farming practices, including fertilizer input, use of high-yielding varieties, irrigation, etc. Yield gains from PPP use are expected to be higher in high productive cropping systems relative to low productive cropping systems, where other culture measures and conditions (e.g. soil, climate) are often sub-optimal. Thus, changes to PPP use cannot be considered in isolation and optimisation of farming practices is required to reduce economic losses.
- The general tendency is for a reduction to be possible for (very) high actual PPP use, but not for low use operations. Lechenet et al., (2014)[409] is cited as an example of how PPP use reduction did not reduce high productivity or high profitability of arable crops in France in 77% of the farms studied, and in particular 59% of the farms achieved a 42% reduction of total PPP treatment without negative economic effects. The remaining 23% of the farms were shown to be in a conflicting situation for pesticide reduction and productivity and/or profitability. Most reductions were thus possible in farms with high PPP use, whereas the conflicting situations were associated with industrial crops characterised by both, high pesticide use and high added

[407] Grey literature is a field in library and information science that deals with the production, distribution, and access to multiple document types produced on all levels of government, academics, business, and organization in electronic and print formats not controlled by commercial publishing i.e. where publishing is not the primary activity of the producing body. Examples of grey literature include: conference abstracts, presentations, proceedings; regulatory data; unpublished trial data; government publications; reports (such as white papers, working papers, internal documentation); dissertations/ theses; patents; and policies & procedures.

[408] European Parliamentary Research Service - Panel for the Future of Science and Technology (2019). Farming without plant protection products - Can we grow without using herbicides, fungicides and insecticides? See: https://op.europa.eu/en/publication-detail/-/publication/793709ec-8e62-11e9-9369-01aa75ed71a1/language-en

[409] Lechenet, M., Dessaint, F., Py, G., Makowski, D. and Munier-Jolain, N., 2017. Reducing pesticide use while preserving crop productivity and profitability on arable farms. Nature Plants, 3(3), pp.1-6.

value. This is further supported by Jacquet et al. (2010)[410], who argued that a 30% reduction of PPPs in French field crops is possible without reducing farmer's income, and Pimentel et al. (1993)[411], who argued that that a 50% reduction of PPPs in the US is achievable without crop losses. However, for those goals to be achievable, crop fields need to be better controlled for pests and diseases by adjusting PPP application schemes.

- Modern PPPs are more specific towards target pests. As a consequence, more frequent applications or mixes of selective PPPs are required when multiple pests appear at the same time.
- The EPRS (2019) concludes that there is a considerable loss of biodiversity by the applications of PPPs, both synthetic as well as biological, but this loss is less than the loss due to changes in land use, which would result from expanding the area devoted to arable land).
- The lower yield in organic farming is partially due to less effective crop protection compared to conventional farming.
- Assuming that a fixed amount of food should be produced to feed the world population, the higher land use requirements of organic production (reported to be approximately 25% less productive than conventional farming in this study) has a negative impact on overall biodiversity at the global level. This impact, whilst not necessarily negating the biodiversity benefits of reduced PPP use, should be acknowledged.
- New technologies in plant breeding (NBTs/NGTs)[412], crop protection, precision/SMART farming, have potential to further decrease the use and dependency on pesticide use.
- Climate change considerations should be taken into account, as global yield losses are projected to increase by 10 to 25% per degree of global mean surface warming, with more acute losses in areas where warming increases both population growth and metabolic rates of insects and new pests and diseases likely to threaten crops in the future.

Bareille and Gohin (2020)[413] point to the contradictory results on pesticide use dependence in the literature and attribute them to differences in the assumptions on farmers' efficiency. Among the examples cited are farmers' claims about the negative impacts on crop yield and production costs due to the additional mechanical control of weeds that would be required and other compensating mechanisms such as increased fertilizer use, leading to a large decrease in income for the French farm sector[414]. On the other side of the argument, scientific studies supporting that pesticide reductions are achievable with limited economic impacts are cited (e.g. by 30% according to Jacquet, Butault, and Guichard (2011)[415]; Boussemart, Leleu and Ojo (2011)[416]; and the previously cited Lechenet,et al., 2014).

[410] Jacquet, F., Butault, J.P. and Guichard, L., 2011. An economic analysis of the possibility of reducing pesticides in French field crops. Ecological economics, 70(9), pp.1638-1648.

[411] Pimentel, D., McLaughlin, L., Zepp, A., Lakitan, B., Kraus, T., Kleinman, P., Vancini, F., Roach, W.J., Graap, E., Keeton, W.S. and Selig, G., 1993. Environmental and economic effects of reducing pesticide use in agriculture. Agriculture, Ecosystems & Environment, 46(1-4), pp.273-288.

[412] Novel Breeding Technologies and New Genomic Techniques

[413] Bareille, F. and Gohin, A., 2020. Simulating the market and environmental impacts of French pesticide policies: A macroeconomic assessment. Annals of economics and statistics, (139), pp.1-28.

[414] CONCORDE (2017): "Produitsphytosanitairesdansl'agriculture:l'urgenced'uneapprochedépassionnée et rationnelle.Lecasduglyphosate,"Discussionpaper,FondationConcorde,France

[415] Jacquet, F., Butault, J.P. and Guichard, L., 2011. An economic analysis of the possibility of reducing pesticides in French field crops. Ecological economics, 70(9), pp.1638-1648.

[416] Boussemart, J.P., Leleu, H. and Ojo, O., 2011. Could society's willingness to reduce pesticide use be aligned with farmers' economic self-interest?. Ecological economics, 70(10), pp.1797-1804.

In their meta-analysis of the elasticity of demand for pesticides, Böcker and Finger (2017)[417] found the price elasticities of demand to be more inelastic in high-value crops (e.g. horticulture, fruit production and viticulture) compared to arable and grassland farming. This can be explained by a) the lower spatial flexibility of fruit production and viticulture; b) the greater importance of quality aspects and the more valuable harvest obtained; c) pesticides are often applied pre-emptively; and d) fewer substitutes exist for these sectors. The authors note the particular relevance of this finding, since "high-value crops usually need the largest amount of pesticides per hectare". Within PPP, herbicide demand is more elastic than fungicides and insecticides. Consequently, the distributional impacts of a blanket 50% reduction target would be significant based on the productive orientation of the farm.

Another recent report on the cumulative impact of hazard-based legislation on crop protection products in Europe published by CropLife Europe[418] was reviewed as part of this analysis. Together the first and second volumes of the CropLife Europe report provide projections on the socio-economic impacts on the production of seven key staple crops and 38 speciality crops in 16 EU countries under more stringent pesticide regulation (i.e. a selected list of 75 substances deemed as high or medium risk, are removed from the farmers' toolbox). Yield and cost change estimations underpinning those projections were obtained through a consultation with a group of experts and extrapolated to the whole of the EU.

Substantial negative effects on yields and farmer incomes are projected by CropLife Europe (yield reduction ranging between 10% and 40% for seven key staple crops the study and even larger negative effectors for speciality crops, up to 100% yield losses for certain fruits and vegetables) together with negative effects on production costs per hectare, halving farmers' incomes. In total, some EUR 14 billion of production value would be lost in the sixteen countries, reducing the competitivity of EU agriculture. On this basis, the authors argue the need for the speed of regulatory change on pesticides to be synchronised with the speed of change at which either society and agricultural systems accept the trade-offs in production and revenues, or the speed at which substances with "superior environmental and food safety profiles can be introduced".

To sum up, the homogenization created by agriculture at farm and landscape level has increased crop vulnerability to pests, disease and climate impacts (see above and section 7.2, Biodiversity), and has in turn driven a greater use of precautionary measures such as chemical pesticides[419];[420]. There is evidence in the literature of the potential presented by IPM approaches, including crop rotation, to revert that trend by achieving a positive crop performance relative to conventional approaches[421],[422],[423]. Together with the implementation of novel technologies such as decision-support systems (DDS), precision agriculture with remote sensing combined with unmanned aerial

[417] Böcker, T.G. and Finger, R., 2017. A meta-analysis on the elasticity of demand for pesticides. Journal of Agricultural Economics, 68(2), pp.518-533.

[418] https://croplifeeurope.eu/report/low-yield-ii-report/

[419] Benton, T., Bieg, C., Harwatt, H., Wellesley, L. and Pudasaini, R., 2021. Food System Impacts on Biodiversity Loss Three Levers for Food Sys-tem Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House, pp.2021-02.

[420] European Parliamentary Research Service - Panel for the Future of Science and Technology (2020). The future of crop protection in Europe. Study. See: https://www.europarl.europa.eu/stoa/en/document/EPRS_STU(2021)656330

[421] Lechenet M, Bretagnolle V, Bockstaller C, Boissinot F, Petit M-S, et al. (2014) Reconciling Pesticide Reduction with Economic and Environmental Sustainability in Arable Farming. PLoS ONE 9(6): e97922. doi:10.1371/journal.pone.0097922

[422] Colbach N, Petit S, Chauvel B,Deytieux V, Lechenet M,Munier-Jolain N and Cordeau S (2020)The Pitfalls of Relating Weeds,Herbicide Use, and Crop Yield: Don'tFall Into the Trap! A Critical Review.Front. Agron. 2:615470.doi: 10.3389/fagro.2020.615470

[423] Bareille, F. and Dupraz, P., 2020. Productive Capacity of Biodiversity: Crop Diversity and Permanent Grasslands in Northwestern France. Environmental and Resource Economics, 77(2), pp.365-399.

vehicles, breeding of resistant cultivars and biopesticides, these approaches can reduce the dependence on PPPs thus limiting the negative productivity impacts of achieving the pesticide-related targets announced in the F2F strategy[424]. However, questions remain as to the impacts on food production and trade and the economic implications of this transition for farmers and across the wider agri-food value chain.

Changes in farm income

Reactions to changes in pesticide price or availability take place at two levels. At the intensive margin, farmers modify their variable input application for one given unit of crop-specific land. At the extensive margin, farmers modify their land use choices among different crops. Therefore, all other things being equal, an increase in pesticide price (and by extension, reduced pesticide availability) will lead to profit- maximizing farmers to not only (i) reduce their use of pesticide at the intensive margin for all crop types but also (ii) favour crops that are the least pesticide-intensive[425].

Thus, changes in farm income driven by a reduction in pesticide use and risk are complex and highly dependent on a range of interconnected variables – not least crop allocation choices, productive orientation and farm management practices, including the cost and pace of uptake of technological development and alternative control methods (e.g. mechanical weeding). Moreover, other external drivers such as climatic variability, incidence of pest and diseases, the evolution of oil prices, together with the extent and pace of adoption of IPM and the application of ecological principles in diversified systems, will influence pesticide dependence and the economic performance of farms.

10.2.2.3 *Conclusions regarding farm productivity and profitability*

The table below presents an overview of the anticipated direction of change on the main farm productivity and profitability indicators resulting from achieving the pesticide targets announced in the F2F strategy, relative to the baseline. Specifically, the baseline column in the table presents and informed judgement on the direction of travel of the selected indicators over the 10-year period, based on the evidence base available and presented above. The second column presents an informed judgement on the additionality of SUD to those indicators, in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved. In this context, an upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator.

The addition of e.g., a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD revision is expected to reinforce the baseline trends, whereas e.g., an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends. However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results.

[424] European Parliamentary Research Service - Panel for the Future of Science and Technology (2019). Farming without plant protection products - Can we grow without using herbicides, fungicides and insecticides? See: https://op.europa.eu/en/publication-detail/-/publication/793709ec-8e62-11e9-9369-01aa75ed71a1/language-en

[425] Bareille, F. and Gohin, A., 2020. Simulating the market and environmental impacts of French pesticide policies: A macroeconomic assessment. Annals of economics and statistics, (139), pp.1-28.

Table 10-3. Anticipated direct and indirect impacts on selected indicators on farm productivity and profitability resulting from achieving the F2F targets on chemical pesticides, relative to the baseline

Indicators	Baseline	Pesticide related targets in F2F
• General production	↓	↓↓
• Agricultural producer prices (at farm gate)	↑	↑↑?
• Production costs	↑	↑↑?
• Gross margin	↓	↓↓?
• Farm income	↔?	↓?
• Total value of crops	↓	↓↓?

Note: anticipated trends depicted by arrows.
? denotes uncertainty in the projection

Limitations of the modelling exercises reviewed as part of this assessment and gaps in the evidence base in relation to pesticide dependence hinder the ability to make predictions both, in the baseline and in the scenario in which the pesticide related targets announced in the F2F strategy are achieved. The outcomes of previous analyses are based on different assumptions around farmers' behaviour and yield impacts, and the results obtained are highly variable.

Questions around the cost and uptake of alternative plant protection methods, including crop efficiency technology, biopesticides and NBTs add further uncertainty, not least considering the regulatory changes and funding required to accelerate their uptake and reduce the economic and food production impacts associated to a reduced pesticide use. Overall, it is considered unlikely that the deployment and uptake of those agricultural technologies will be conducted at the pace needed to avoid yield reduction resulting from a reduced pesticide use even in the baseline unless strong regulatory support is introduced, including economic subsidies to reduce capital expenditure barriers.

The anticipated decrease in production, driven by an overall reduction in yield and, for certain cereals and oilseeds, also a reduction in cropped area, is expected to induce production price increases. The literature suggests that the increase in price will not be sufficient to outweigh the loss in yield despite lower costs from reduced inputs, even when the cost of alternative plant protection technologies (IPM, mechanical weeding) is considered. When agri-tech is considered, despite the additional yield protection, the capital investment required for the technology will impact farm income. In addition, trade effects would influence producer prices over the medium to long term, further challenging the economic return of farmers in both scenarios.

Overall, the literature shows stronger negative impacts on arable crops than on permanent crops or vegetables although there is no consensus. Moreover, organic farms are expected to have reduced impact or even see a benefit given the price premium of organic products, provided that both CAP support and the price premiums are maintained (i.e., there is sufficient demand for organic products), whereas the impact is expected to be stronger in conventional farms despite the feedback effects linked to land-use and price changes. It can be concluded that whilst the extent of the impacts is disputed, there is a general agreement that the impacts will be unequally distributed.

The expectation is that the CAP contributions would in general terms support current farm income levels on the average, and promote the adoption of agri-tech, but the degree to which the negative economic impacts on farm productivity and profitability will be countered is unclear, particularly in the scenario in which the 50% reduction targets are achieved as the CAP budget requirements would be larger.

10.2.3 Impacts on PPP and PPP application value chain

10.2.3.1 Estimation of the 2020-2030 baseline

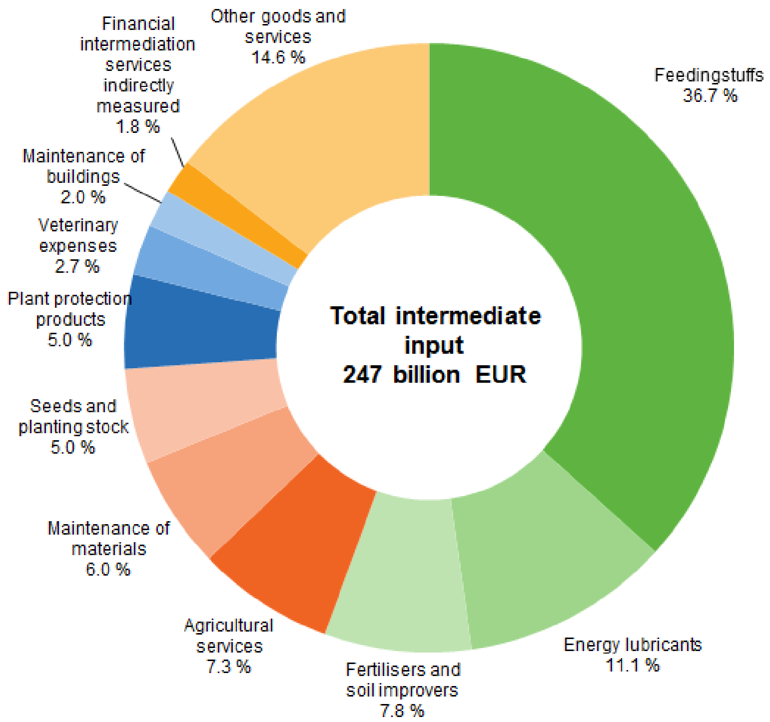
Economic operators involved in the distribution and use of pesticides comprise agricultural inputs, machinery and services (e.g. agricultural contactors, extension services and crop marketing). Against this complex and varied upstream value chain, research is patchy (there are no indicators on the role of agricultural contractors on the European Farm Structure Survey for example) and no integrated analysis of all upstream products and services has been identified. The following sections present an overview of the main economic operators and anticipated trends in the PPP value chain.

Agricultural inputs

Current situation

Intermediate input cost data reported by Eurostat[426] for 2015 comprises purchases made by farmers for raw and auxiliary materials used as inputs for crop and animal production, expenditure on veterinary services, repairs and maintenance costs and costs for other services (i.e. input goods and services). Intermediate input cost within the EU-28's agricultural industry in 2015 was valued at EUR 246.5 billion at basic prices (60.0% of the value of agricultural output generated), down from a 2014 value of EUR 252 billion (60.2%).

Figure 10.9. Breakdown of costs of intermediate inputs.



Note: values at basic prices.

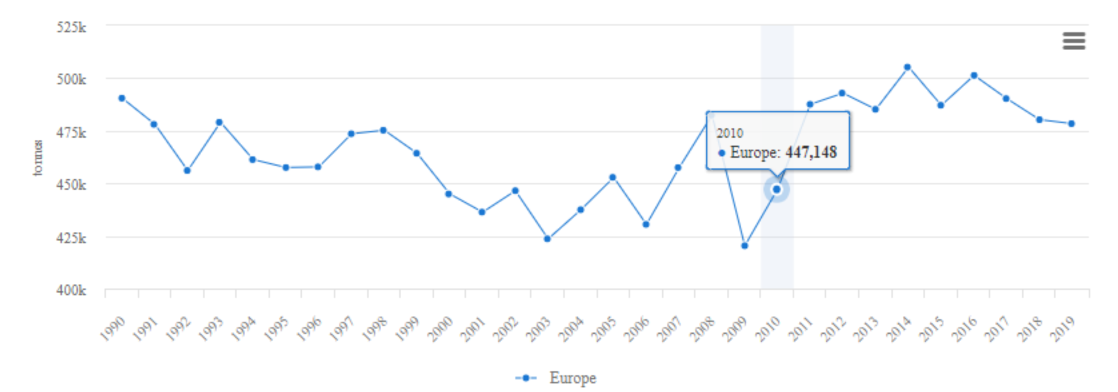
Source: Eurostat

[426] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_accounts_and_prices&oldid=327069

Plant protection products accounted for 5% of the total intermediate inputs within the EU-28's agricultural activity in 2015. Feeding stuffs for animals accounted by far for the highest share (36.7%), three times the share of energy and lubricants (11.1%)[427]. Soil improvers (7.8%) accounted for the highest share of intermediate inputs among those inputs used exclusively for crop production (see Figure 10.9). Three main intermediate inputs are used for the production of crops: seeds and plantings, fertilisers, and plant protection products which together accounted for 20.7% of the production value of crops in the EU-28 in 2015 (2.1% higher than in 2010).[428].

Pesticide use varies significantly based on the productive orientation, economic structure and location of farms (refer to 10.2.2). In the aggregate, according to the FAO database on pesticide use[429][430], pesticide sales in Europe over the last ten years have seen an upward trend but remain comparatively similar to the quantities used in 1990.

Figure 10.10. Total pesticide sales in Europe



Source: Own illustration using FAO data

However, average trends mask the spatial distribution of pesticide sales and changes in pesticide use (refer to Figure 10.12) across Member States.

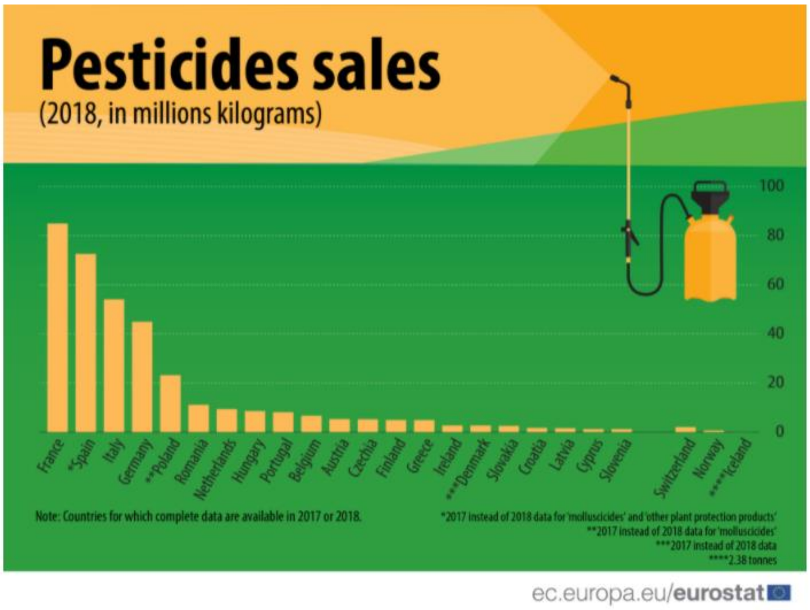
[427] This percentage corresponds to energy and lubricant use for both animal and crop production

[428] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_accounts_and_prices&oldid=327069

[429] http://www.fao.org/faostat/en/#data/RP/visualize

[430] The Pesticides Use database includes data on the use of major pesticide groups (Insecticides, Herbicides, Fungicides, Plant growth regulators and Rodenticides) and of relevant chemical families. Data report the quantities (in tonnes of active ingredients) of pesticides used in or sold to the agricultural sector for crops and seeds. Information on quantities applied to single crops is not available.

Figure 10.11 Pesticide sales across Member States



Source: Eurostat

Figure 10.12. Changes in total pesticide sales at Member State level

Source: Eurostat

From a market perspective, and according to a review of the agricultural inputs sector in the EU conducted Wesseler et al., 2015[431], the number of enterprises producing plant protection products has maintained relatively steady in the period 2003 to 2012 (varying between 630 and 655). Germany, France, the UK, Italy and Spain are the countries with the highest industry turnover for the period, concentrating more than 80% of total sales. The European plant protection industry appears highly concentrated, with an estimated market share of the five largest companies (CR5)

[431] Wesseler, J.H.H., Bonanno, A., Drabik, D., Materia, V.C., Malaguti, L., Meijer, M. and Venus, T.J., 2015. Overview of the Agricultural Inputs Sector in the EU. European Union.

spanning between 79% and 83%, and calculated Herfindahl-Hirschman Index (HHI)[432] values varying between 1556 and 1717.

The number of patents in the industry has seen a considerable decline in the last decades[433]. Limitations on the registration of broad-spectrum agrochemicals have resulted in many new active ingredients being single site active, which is perceived to increase the potential for resistance development. Reregistration requirements have further driven the decline in the number of active ingredients in the EU crop protection market, resulting in a lower number of agrochemical products being available for EU farmers when compared with other jurisdictions. This trend is driven by longer product development cycles and higher costs, and has been reinforced by the diversion of R&D budgets to other crop protection technologies (e.g. genetically modified (GM) seed, biologicals and other alternative technologies). The change in market dynamics over the last 20 years have resulted in greater growth in developing countries (both volume and value growth) rather than in the mature markets (North America, EU-15 and Japan) that are the major focus of new active ingredient research and development (R&D). As a result, the limited value growth from product substitution has become the main growth driver in mature countries. This trend has not been altered by recent consolidation in the EU industry. Yet as a sign of the potential economic success of R&D, even though less new chemistry is being introduced, the fastest growing chemistry sectors are all driven by recent agrochemical introductions[434].

Against this backdrop, investments in R&D and product development for companies operating in the EU crop protection industry remain large in absolute terms and can play a role of sunk costs acting as barriers to entry and fostering further consolidation (Wesseler et al., 2015).

Outlook on agricultural inputs

The dynamic baseline was informed by the 2020-2030 EU Agricultural Market Outlook[435] and further adapted since the potential impacts of the F2F and BDS strategies on food production within the EU are not incorporated in the EC (2020) analysis.

Overall, the EC (2020) projects nominal farm intermediate input costs to increase by 16%, reaching EUR 251 billion in 2030. The share of improved, lower-risk plant protection products is anticipated to increase in the baseline thanks to continuous investments in R&D to meet productivity gains and environmental standards. The demand for and production of biopesticides is also projected to increase in the baseline. Overall use of plant protection products is expected to slow down, thanks to better targeting and improved management through digital technologies, together with the projected increase in organic farming. Energy and other input costs (e.g. veterinary expenses, maintenance, temporary labour and machinery rent) are also projected to rise following the recovery of GDP in the aftermath of the COVID-19 crisis. As previously noted (see discussion on pesticide dependence in section 10.2.2), the distribution of costs is expected to vary significantly at farm level based on their productive orientation, economic structure and location. Changes to PPP use cannot be considered in isolation as attempts to reduce economic losses will lead to wider crop allocation choices and changes in productive orientation and farm management practices. Impacts on costs of agricultural inputs (and yield) are highly dependent on a range of interconnected

[432] The HHI of a market is calculated by summing the squares of the percentage market shares held by the respective firms

[433] (Wesseler et al., 2015).

[434] Phillips, M.W.A., 2020. Agrochemical industry development, trends in R&D and the impact of regulation. Pest management science, 76(10), pp.3348-3356.

[435] EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels. Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2020-report_en.pdf

variables, including the cost and pace of uptake of technological development and alternative control methods (e.g., mechanical weeding).

The impact of the reduced pesticide use in the EU for the plant protection products industry will be determined by the retail price and market share of new products. Additional factors include R&D and production costs and the overall volume of exports of plant protection products to non-EU countries, however those drivers are independent of the proposed policy changes to the SUD and are therefore out of the scope of this assessment. In response to the various policy changes and market disruptors, some companies have gone beyond consolidation and are already diversifying their services (e.g., investing in biologicals, collaborating with or acquiring companies in the digital space – farm management software and services – reformulating their products that will go off-patent into new marketable solutions, use of novel technologies to reduce time-to-market of new products and reduce R&D intensity)[436].

Agricultural machinery

According to the European Agricultural Machine Association (CEMA), the EU manufacturing sector for agricultural machinery includes 7,245 industrial firms employing 173,142 people for a total turnover of EUR 42.9 billion When bundling the agricultural machinery industry and trade activities, the sector accounts for 30,708 firms and 352,295 employees[437].

Agriculture in the European Union has traditionally been a labour-intensive sector characterized by a higher number of seasonal immigrant workers working on farm fields in the Member States. However, recent shortages of farm labour exacerbated by COVID-19 and Brexit is giving way to rise in wage rates, thereby allowing the farmers to adopt farm mechanization including tractors in the region. Furthermore, companies are heavily investing in technologies such as drones and driverless sprayers, with together with GPS mapping and simulation modelling are supporting the precise application of pesticides that results in higher yields and reduce environmental externalities. This is resulting in an unprecedented growth of precision farming. These developments, coupled with the rising importance of agriculture and a decreasing crop acreage, are likely to further enhance mechanisation in the EU [438][439][440].

Agricultural contractors

In the absence of official statistic for the sector, the European Confederation of Agricultural, Rural and Forestry Contractors (CEETTAR) has estimated that about 150,000 agricultural, rural and/or forestry contractors, involving about 600,000 persons, are operating within the territory of the European Union, executing in average 50% of work in the sector (up to 90% for some harvesting activities)**.** According to a study carried out by CEETTAR and the Lublin University, the value of services provided by agricultural contractors in the agricultural sector represents about 10% of the value of the agricultural production of the Member States, reaching in some cases 20% [441].

The sector is dominated by small and medium-sized enterprises, with an estimated 600,000 people directly employed (including managing directors and self-employed workers) at Community level. In addition, the services that they provide for the agricultural/forestry sectors and local authorities cover a wide variety of professions and operations covering: 1) all types of agricultural work, such

[436] https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/agricultural-chemical-industry-outlook.html

[437] https://www.cema-agri.org/images/publications/brochures/2019_CEMA_report_priorities_key_figures_web.pdf

[438] https://www.mordorintelligence.com/industry-reports/europe-agricultural-machinery-market

[439] https://www.mordorintelligence.com/industry-reports/europe-agricultural-tractor-machinery-market

[440] https://www.mordorintelligence.com/industry-reports/europe-agricultural-sprayer-market

[441] Caldier, P. and Drésin, E., 2018. European panorama of the agricultural, rural and forestry contractors. Bruselas: Ceettar

as soil cultivation, fertilisation, harvesting, transport, livestock and agricultural management services; 2) a wide range of maintenance and management services for rural areas, focusing on networks (communication, infrastructure), the environment and public spaces; and 3) a wide range of forestry/reforestation, maintenance and farm management services for forest owners, farmers, suppliers and timber companies.[442] [443]

Contractors use a large amount of technology advanced machinery, supporting the use innovative technologies for agricultural, rural and forestry activities (rather than the direct purchase of technology by farmers), as well as the employment of skilled workers. This in turn contributes to a better use of resources (by reducing costs and increasing profitability for farming activities) and environmental protection, including for small size exploitations[444]. Thus, the demand for and use of agricultural contractors is anticipated to significantly grow in the baseline.

Agri-tech

Agri-tech applications (i.e. technology and technological innovations to improve the efficiency and output of agricultural processes) are undergoing an unprecedented level of development. Spurred by the combination of global pressures resulting from climate change and a growing population with rising incomes, the agri-tech sector develops solutions aimed at increasing yield, reducing farm inputs and reducing environmental costs, to reduce productivity losses and improve food supply chain efficiency and access to/cost of finance to farmer. Particular developments are undergoing in[445]:

- Crop efficiency technology (smart), including agricultural data analytics, robots, drones, sensors, internet of thigs (IoT) monitoring, farm equipment sharing, efficient irrigation systems, soil and crop technology, smart phenotyping, satellite imagery;
- Biologically produced agrochemicals, micro- and nano-based bioengineering and bio-crops; and
- The development of new breeding techniques (NBTs) speeding-up the development of resistant cultivars

Farmers account for most potential end users, however the potential for uptake for smart technologies is highly influenced by farm size due to the large capital investments required. This issue is particularly acute for innovations that give farmers access to data and not just mechanisation, where the long-run returns are often higher but less visible in the short-run and the value proposition of new technologies is less visible despite the savings in the long run and/or improvements in crop yields[446] [447]. This causes the adoption of digital technologies to diminish with increasing farmer age and decreasing farm size due to fixed costs of equipment (Tamirat et al., 2018[448]). Whilst that poses a limitation for agri-tech firms in the EU market, it also presents a potentially large and untapped opportunity for companies that can develop low-cost agri-tech that can deliver benefits for small holdings. The value proposition for agri-tech also differs substantially between developed and developing world markets. In the former, high labour costs suggest a cost-

[442] https://www.ceettar.eu/sectors.php?cat=1

[443] Caldier, P. and Drésin, E., 2018. European panorama of the agricultural, rural and forestry contractors. Bruselas: Ceettar

[444] https://www.ceettar.eu/news.php?item=42

[445] https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-industrial-products/Deloitte-Tranformation-from-Agriculture-to-AgTech-2016.pdf

[446] Catapult Satellite Applications, 2017. Agricultural technology market review. Available at: https://sa.catapult.org.uk/wp-content/uploads/2018/12/Agri-tech-Market-Report_090617.pdf

[447] https://ceettar.eu/uploads/docs/bib/ceettarpositionpaperfarmtoforkstrategyen.pdf

[448] Tamirat, T.W., Pedersen, S.M. and Lind, K.M. 2018. Farm and operator characteristics affecting adoption of precision agriculture in Denmark and Germany. Acta Agriculturae Scandinavica, Section B. Soil &. Plant Sci., 68(4): 349–357. doi:10.1080/09064710.2017.140 2949.

case argument for agri-tech. To succeed in the latter, where there is an abundant source of cheap labour, the value proposition of agri-tech must focus on reducing risk and improving the resilience of farms. Additional challenges for uptake include poor usability of some agri-tech and sometimes product incompatibility across platforms and large set-up times, as well as poor internet connectivity in rural areas. The latter in particular can hinder the adoption of powerful IoT and connectivity technologies that can integrate sensors and coordinate farming assets across farming estates (Catapult SA, 2017[449] [450]).

Overall, attempts to quantify the role of digitalization in reducing pesticide inputs in the literature are limited, as this would require a baseline of current use. Guyomard, Bureau et al. (2020[451]) have estimated that precision farming could allow a reduction by 10 to 20% of pesticide use, however this is dependent on accompanying actions required to encourage adoption. It is generally accepted that digitalisation will provide efficiency gains and resources saving, but it also presents limitations. The extent to which such limitations are addressed will determine the realization of its full potential and the avoidance of its negative effects. Overall, digitalization on its own will not result in better or sufficient protection for the environment and needs to be clearly linked to and guided by ambitious targets on pesticide use reduction, lower nutrition surpluses or lower livestock density. Furthermore, if rebound and shifting effects are not avoided, efficiency gains could be partially or fully negated by additional consumption. Prerequisites for the use of digital technologies including AI are rapid grid development, the advancement of data infrastructures, and the exploitation of the advantages of open data, open source and (open) standards for interfaces. Enablers required, in addition to public investment and legal certainty on product liability and product safety, include training, advice and information on new technologies, as well as appropriate research funding, whereby digitalization in the agricultural sector and beyond is tied to sustainability objectives[452].

On a different end of the spectrum, concerns about inequality, governance and pathway dependence raised by digital technologies have been raised by critics. Digital agriculture supports sustainable intensification approaches but can in turn increase dependency on a few input and retail companies (e.g., companies who own the platforms and equipment and control the data) and decrease the resilience and equity of food systems. This could lock producers and citizens into asymmetrical power relationships with large companies, and potentially close off possible alternative food options that do not satisfy primary industry goals (HLPE, 2019), although these concerns could be (at least partially) balanced by alignment with sustainable policy targets. To overcome these challenges, the focus of innovations requires a shift from the introduction and spread of adoption of new technologies to the promotion of: (i) inclusive and participatory forms of innovation governance; (ii) information and knowledge co-production and sharing among communities and networks; and (iii) responsible innovation that steers innovation towards social issues more aligned with agroecological concepts (HLPE, 2019).

Biologically produced PPPs have long been used in crop protection, either through direct use or as inspiration for other agrochemicals. However, as agricultural fungal, weed and insect pests continue to change, the requirement to continually develop new, natural routes for plant protection agents

[449] Catapult Satellite Applications, 2017. Agricultural technology market review. Available at: https://sa.catapult.org.uk/wp-content/uploads/2018/12/Agri-tech-Market-Report_090617.pdf

[450] https://ceettar.eu/uploads/docs/bib/ceettarpositionpaperfarmtoforkstrategyen.pdf

[451] Guyomard, H., Bureau J.-C. et al. (2020), Research for AGRI Committee – The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU's natural resources. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

[452] Garske, B.; Bau, A.; Ekardt,F. Digitalization and AI in EuropeanAgricultureEuropean Agriculture: A Strategy for AchievingClimateAchieving Climate and Biodiversity Targets?Sustainability2021,13, 4652. https://doi.org/10.3390/su13094652

remains as critical as ever (Loiseleur, 2017[453]). Yet, although the potential of both living organisms and natural agrochemical compounds is recognised and there has been significant recent investment in their research, their current role in the crop protection market remains limited.

Biocontrol refers to all methods, tools, measures and agents of plant protection that rely on the use of beneficial organisms and they natural mechanisms and interactions to steer the relationship of biological species with their natural environment. These include the use of arthropods, microorganisms, nematodes, viruses and products derived from these organisms for crop protection. Over the past decade the rate of introduction of biological products has exceeded that of conventional PPP, however biocontrol agents represent less than 5% of the sales of PPP. Options are available particularly for protected cropping systems such as vegetables, fruits and ornamental plants grown in greenhouses, but are still limited for arable systems and their use requires combination with synthetic PPPs as they are seen by farmers as less efficient and reliable. Biocontrol agents generally present narrower spectrums of application of crop/pest combinations and various products are typically applied, increasing the cost to farmers (European Parliamentary Research Service, 2020).

Micro- and nanotechnologies are held back by a lack of regulations regarding their authorisation and introduction, as well as gaps in knowledge surrounding their potential risks, higher costs of production, and perceived lower effectiveness and lack of persistence[454].

Similarly, the EU's complex legal landscape and strictness of authorisation regulations have been linked to comparatively low European adoption rates of bio-crops, GMO products and products developed using new breeding techniques (NBTs), all of which have potential for significant growth should these regulatory barriers be eased[455].

Breeding – through conventional or new, genome editing techniques[456]- enables the development of new crop varieties with good characteristics, such as resistance against specific pests or diseases or tolerance to/suppression of weeds, reducing the need for chemical pest control and limiting environmental and human health impacts. Furthermore, the introduction of new resistant varieties protects farm's income by reducing the cost of pesticide application. The overall contribution of new breeding techniques to the competitiveness of EU farming will be determined by the evolution of the legal framework regulating their use in the EU and elsewhere (European Parliamentary Research Service, 2020)[457]. Lastly, application of ecological principles is emerging as a strategy to increase the stability and resilience of crops, by increasing plant diversity (temporal, spatial and genetic) in and around cropping fields. Whilst the impact of this technique is difficult to quantify and variable, the beneficial effects of increased diversity on cropping systems is generally recognized (Letourneau

[453] Loiseleur, O., 2017. Natural products in the discovery of agrochemicals. *CHIMIA International Journal for Chemistry*, *71*(12), pp.810-822. https://www.ingentaconnect.com/contentone/scs/chimia/2017/00000071/00000012/art00003?crawler=true&mimetype=application/pdf

[454] Vurro, M., Miguel-Rojas, C. and Pérez-de-Luque, A., 2019. Safe nanotechnologies for increasing the effectiveness of environmentally friendly natural agrochemicals. *Pest management science*, *75*(9), pp.2403-2412. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ps.5348?saml_referrer

[455] Zimny, T., Sowa, S., Tyczewska, A. and Twardowski, T., 2019. Certain new plant breeding techniques and their marketability in the context of EU GMO legislation–recent developments. *New biotechnology*, *51*, pp.49-56. https://www.sciencedirect.com/science/article/pii/S187167841831940X

[456] Breeding techniques such as mutation breeding, GMO and gene transfer techniques have been supplemented in recent years with the development of a range of new plant breeding techniques (NPBTs) that adjust the genetic make-up of crops, enabling the precise and effective improvement of crops traits where crossbreeding has not succeeded. Techniques including genome editing (or directed mutagenetic) are used as a tool during the breeding process, however no DNA from non-crossed species is present in the end product.

[457] European Parliamentary Research Service - Panel for the Future of Science and Technology (2020). The future of crop protection in Europe. Study. See: https://www.europarl.europa.eu/stoa/en/document/EPRS_STU(2021)656330

et al, 2011)[458]. However, given that productivity trade-offs could trigger the need for the expansion of agricultural areas, a balanced approach focused on diversification strategies that improve the sustainability of conventional farming systems is required[459].

10.2.3.2 *Estimated impacts from achieving the Pesticide-related targets announced in the F2F strategy*

Impacts on the PPP value chain resulting from achieving the pesticide-related targets announced in the F2F strategy are inexorably linked to synergistic agricultural practices encouraged by the F2F, Biodiversity Strategies and the CAP such as the target to reach 25% of agricultural land under organic farming by 2030. They are therefore difficult to unpick from the impacts arising from the new policy landscape, together with the wider megatrends (i.e. global population growth; societal and demographic changes; increasing urbanisation; smart agricultural technology; biotechnologies; climate change; globalised trade; value chain integration; increasing complexity of international regulations; and servitisation of agrochemical suppliers around core products) and sector-specific change accelerators (new consumer preferences; emerging technologies and changing configuration in the agricultural ecosystems though horizontal integration of adjacent service offerings; digitalisation and vertical integration of input suppliers)[460].

All of these drivers will largely influence the productive orientation and economic structure of farms going forward, as well as investment in, and pace of development and uptake of agri-technology. Overall, a reduction in pesticide use and risk will require an uptake of digital technologies, mechanisation and farming services. In turn, these developments would increase the demand for agricultural machinery and contractors.

10.2.3.3 *Conclusions regarding PPP value chain*

The table below presents an overview of the anticipated direction of change on the main indicators of the PPP value chain resulting from achieving the pesticide targets announced in the F2F strategy relative to the baseline. Specifically, the baseline column in the table presents and informed judgement on the direction of travel of the selected indicators over the 10-year period, based on the evidence base available and presented above. The second column presents an informed judgement on the additionality of SUD to those indicators, in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved. In this context, an upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator. The addition of e.g., a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD revision is expected to reinforce the baseline trends, whereas e.g., an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends. However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, particular uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results.

[458] Letourneau, D. K., Salguero, B., and Montoya-Lerma, J. (2011). Does plant diversity benefit agroecosystems? A synthetic review Mathematical models and methods for surveillance and control of dengue fever View project. May 2014, 2019. https://doi.org/10.2307/29779633

[459]Bellouin et al., 2019; European Parliamentary Research Service, 2020

[460] https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-industrial-products/Deloitte-Tranformation-from-Agriculture-to-AgTech-2016.pdf

Table 10-4. Anticipated impacts on selected indicators of the PPP and PPPP application value chain

Indicators	Baseline	Pesticide related targets in F2F
Pesticide use	↓	↓↓
Agrochemical suppliers (PPP)		
• Number of enterprises	↓?	↓?
• Employment (FTE)	↓	↓?
Agricultural machinery		
• Number of enterprises	↑?	↑↑?
• Employment (FTE)	↑?	↑↑?
Agricultural services (PPP application, training, etc)		
• Number of enterprises	↑?	↑↑?
• Employment (FTE)	↑?	↑↑?

Note: anticipated trends depicted by arrows.
? denotes uncertainty in the projection

Consolidation of local and regional players in the European agrochemicals industry will likely see the number of enterprises to continue to diminish, whereas the diversification and servitisation of the agrochemical suppliers is expected to continue. It is anticipated that agrochemical companies will move to R&D in the biopesticides sector, given the lower costs relative to R&D for chemical pesticides. On the other hand, the lack of intellectual property protection mechanisms on bioproducts may limit investments by multinational in the field. Achieving the pesticide related targets announced in the F2F strategy will further reinforce the trend rather than creating an additional disruption.

When considering the outlook for agricultural machinery, assumptions in relation to crop type and use of plant protection products in the baseline are critical, as is the choice and cost of farm management practices and alternative control methods (e.g. mechanical weeding). Overall, a reduction in pesticide use is expected to be enabled by the increased uptake of precision agriculture and alternative pest control methods including mechanical methods.

Finally, a reduction in pesticide use is anticipated to further reinforce the growth in demand for agricultural contractors to support the uptake of technology advanced machinery, including precision agriculture, provided that the cost gap is addressed either though higher food prices and/or subsidies/additional funding through the new CAP.

10.2.4 Impacts on agri-food value chain

10.2.4.1 Estimation of the 2020-2030 baseline

Composition of the agri-food value chain

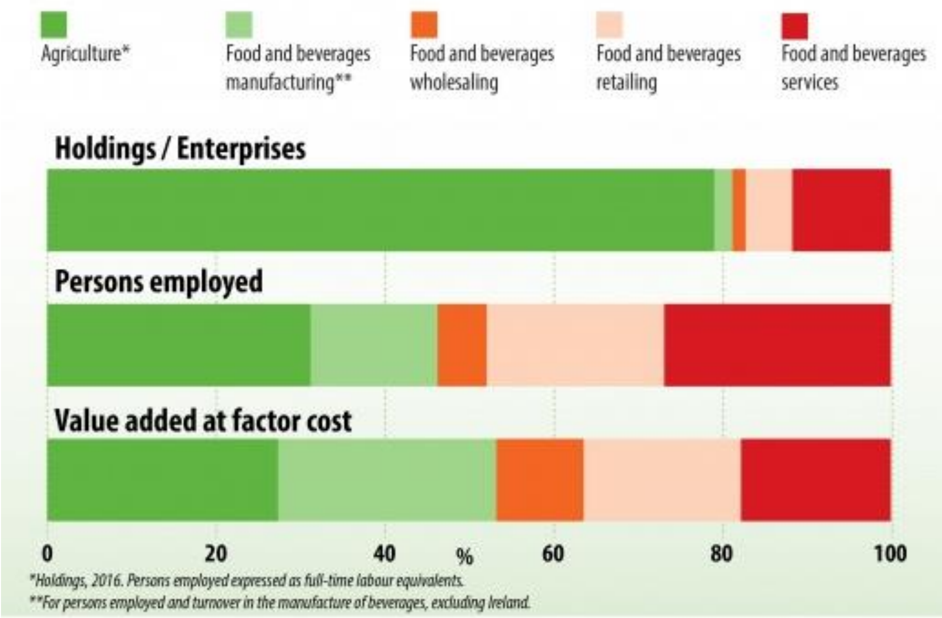
EU agricultural value chains are resilient, diverse and flexible, supporting approximately 43 million jobs which provide food and non-food products for the EU's 500 million consumers. Farm production itself accounts for around 22 million of these jobs and represents the base of the agri-food value chain, but three other key stages are also significant contributors to the sector's value-added: processing, distribution and retail (Figure 10.13[461] and Figure 10.14[462]).

[461] https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-3-farmer-position-in-value-chains_en.pdf

[462] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=From_farm_to_fork_-_a_statistical_journey

Figure 10.13. Employment in the agri-food sector

Figure 10.14. From farm to fork – structure of the food chain, 2017 (%)



Unless otherwise indicated, data for the following sections has been obtained from Eurostat[463].

Farm production stage

In the EU, farm production – the process of growing crops and raising livestock – is made up of 10.3 million agricultural holdings characterised by typically (96.3%) family farms, the majority of which (66.6%) were smaller than 5 hectares in size in 2016. Approximately half (52.9%) of these

[463] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=From_farm_to_fork_-_a_statistical_journey#Farm_production_stage

farms specialised in crop production in 2016, one quarter (24.5%) in livestock raising and most remaining farms (21.4%) were mixed in their production.

In 2016, 37.2% of the EU-27's total land area was characterised as managed farmland, of which 62% was arable, 31.2% permanent grassland and 5.5% used for permanent crops such as fruit, olives and grape production. As of 2018, organic farming covered approximately 8.3% of total utilised agricultural area, at around 13.0 million hectares.

Full-time jobs in agriculture numbered around 8.8 million in 2019, with demographics skewed towards relatively older males. The value of all crops, animals and other agricultural services produced by the EU-27's agricultural sector in 2018 was an estimated EUR 404.7 billion (at a cost of EUR 233.3 billion in input costs), of which crops and animals were by far the largest contributors at 53% (EUR 214.4 billion) and 38.5% (EUR 155.8 billion), respectively. Of the total value of EU-27 agriculture, 59% was generated by just four nations – France (EUR 77.2 billion), Italy (EUR 56.9 billion), Germany (EUR 52.7 billion) and Spain (EUR 52.2 billion). Altogether, the gross value added by the EU's agricultural industry was an estimated EUR 171.5 billion in 2018.

Food processing stage

Although a small proportion (~2% in 2015[464]) of agricultural sales are "direct" (i.e., sold by the farmer direct to the consumer), food processing and distribution make up a significant proportion of the agricultural supply chain, and a disproportionate amount of value added.

Approximately 280,000 enterprises in the EU-27 manufactured food and beverages in 2017, plus around 4,900 dairy enterprises (2018 figure). Together, these businesses provided employment to 4.4 million people in 2017, turning over EUR 930 billion in food manufacturing in 2017 and EUR 151 billion in beverages (for the 26 Member States with data available).

The EU food processing sector is characterised by small and medium enterprises; around 95% employed fewer than 50 persons in 2017, and ~80% employed fewer than 10.

Food distribution stage

Wholesalers and retailers comprise the EU's food distribution supply chain tier, operating between producers and consumers. Approximately 203,000 enterprises specialised in wholesaling in 2017, on top of 719,000 enterprises specialising in food and beverages. As these enterprises comprise of restaurants, bars, cafes, catering services and stores where the sale of food dominates, the sector is a major employer, providing work to around 15.6 million people – especially in southern Europe where tourism and café culture is especially apparent.

Regarding transport, around 1.2 billion tonnes of primary agriculture, hunting, forestry and fishery products were transported by EU-27 trucks in 2017 and 2018 – including both EU produced good and imports from outside the EU. A further 1.5 billion tonnes of food products, beverages and tobacco were also transported in 2017. Both figures highlight only trucks with a loading capacity of at least 3.5 tonnes.

Consumer stage

As every EU citizen is a member of the European food value chain, this stage accounts for roughly 500 million people. On average, food and beverage purchases (including catering services) accounted for a combined 21.5% of consumption expenditure of EU-27 households in 2018. This total includes food (11.8%), catering services (6.8%), alcoholic beverages (1.6%) and non-alcoholic beverages (1.2%). However, 21.5% is very much an average value; the average spent on food as

[464] https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/trade/documents/agri-market-brief-04_en.pdf

a proportion of income tends to decline as average income rises. This contributes to some discrepancies between Member States – households in Romania and Estonia spent 30.9% of their incomes on food and beverages, compared to just 16.6% and 17.3% in higher-income Germany and Luxembourg, respectively.

Resilience to price and other shocks across the agri-food value chain

Farm productivity and profitability are discussed in section 10.2.2 above. This section provides an overview of the main categories of actors in the agri-food value chain, with a view to inform the evolution of key economic indicators over the baseline and in the scenario in which the pesticide related targets announced in the F2F strategy are achieved.

Chain composition and concentration

The food supply chain is highly consolidated, characterised by a power imbalance between strong agents operating in concentrated sectors in the downstream stages (i.e., industrial and retailing) and weaker agents in highly disaggregated sectors such as small farmers and consumers (Luca et al., 2018[465]; van der Ploeg et al., 2016[466]).

The EU food and drink processing tier of the value chain is very fragmented. As stated above, Eurostat data[467] classifies 95% of the total (~284,900) enterprises manufacturing food and drink in 2017 as small companies (fewer than 50 employees) and ~80% as micro-companies (fewer than 10 employees). The market share of the top five firms (or C5 concentration ratio) in the EU food industry varies by source, with estimates of an average of 56% in 2012 in 14 of the EU's Member States[468], and a moderate 15% in a majority of Member States in 2016, although there is a general recognition that the ratio increases for certain sectors with more specialised food industries with ratios exceeding 60% in the food and confectionery sector and around 30% on average in processed meat and vegetable products (DG Agri, 2018).

The food distribution tier is highly concentrated, particularly within the retail sector. In 2015, just 10 large retailers/supermarkets controlled 40% of the European food market and in most Member States, three to five large retailers held over 65% of the market share. Approximately 71% of the total packed food sales is distributed through primarily through supermarkets, hypermarkets and discounters. Concentration increases amongst the retail tier are also being influenced by the formation and development of international buying groups (IBGs). The EU has five major IBGs, each larger than any single retailer and of the 10 largest retailers in the EU, six are members of an IBG. However, despite their size and focus on a wide range of agricultural products from pasta and rice to sugar and olive oil, only an estimated 5% of total volume purchased by individual retailers is done through IBGs, perhaps limiting their relative impact on the food supply chain compared to individual retailers.

On the supply side, the majority of the 12.2 million agricultural holdings are small units in terms of physical and economic size. Moreover, the structural characteristics of agriculture in EU-15 are

[465] Luca, C., Russo, C. and Alessandro, S., 2018. Market power and bargaining power in the EU food supply chain: the role of Producer Organizations. New Medit: Mediterranean Journal of Economics, Agriculture and Environment= Revue Méditerranéenne d'Economie Agriculture et Environment, 17(4).

[466] van der Ploeg, J.D., Ventura, F. and Milone, P., 2016. Research for Agri Commitee-Structural Change in EU Farming: How can the Cap Support a 21st Century European Model of Agriculture?: Research for Agri Commitee-Farm Structural Change in Western Europe and The CAP.

[467] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=From_farm_to_fork_-_a_statistical_journey#Farm_production_stage

[468] https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/food-supply-chain_en.pdf

decisively different than those observed in EU-13. The average physical farm size and the average standard output per year in the former are, respectively, three and seven times higher than in the latter. To strengthen their position against increasing levels of consolidation in the retail sector and food and drink industry, farmers rely on mergers, acquisitions, cooperatives and/or cooperation agreements, with a total of 21,769 cooperative companies reported in the EU in 2015. However, the level of cooperation varies by country and sector, with most of the cooperative being small companies[469] [470].

Consolidation helps achieve economies of scale and can lead to efficiency gains and lower mark-ups, in turn improving innovation and quality and reducing prices. However, it also reduces the number of players downstream in the food chain, endowing them with greater bargaining power when negotiating with agricultural producers[471]. Farmers thus need to respond to changing demand of consumers, channelled to them through other actors in the food chain[472].

Value added in the food supply chain

European farmers are faced with a number of key challenges. Compared to the global average, the EU agricultural production market is known for its high production costs, driven by higher environmental and sanitary production standards, increased costs linked to land and labour, and as previously mentioned, the fragmented nature of the EU's farms compared to downstream tiers of the value chain. With added pressures of land availability as forest cover increases across the EU relative to agricultural land, as well as climate change and changing dietary preferences, European farmers have witnessed considerable price volatility in recent years and seen their share of value added within the supply chain remain low or even fall for the last several decades (European Commission[473]). Pressure on agriculture is compounded by the decreasing return per unit of input after a certain, relatively early, point (Law of Turgot). As the output per unit of input is gradually lower as inputs are increased, agricultural producers are limited on the amount of income they can make from inputs and land available (DG Agri, 2018).

By contrast, downstream actors have expanded their share of value added on the back of increasing consumer demand for convenience products and services stimulated by the changes of lifestyle, urbanisation, consumer preferences and general economic environment (DG Agri, 2018; EU Agricultural Markets Brief, 2015[474]).

The gross value added generated in the food supply chain has been growing by 2.4% annually since 2008 and amounts to slightly less than 7% of the total value added of the EU economy. However, the value added of the agricultural sector has grown at a slower pace since 2008 (+1% annually) than other segments of the food supply chain (+2.5% annually for processing; +3.2% annually for

[469] European Parliament (2015) - Policy Department B based on data from European Commission (2015), 'Parliamentary Questions, Question for written answer to the Commission on the Food Supply Chain, E-000251/15.

[470] European Parliament (undated) Committee on Agriculture and Rural Development. Contribution in view of the public consultation on the Guidelines on the application of the specific rules set out in Articles 169, 170 and 171 of the CMO Regulation for the olive oil, beef and veal and arable crop sectors. Available at: https://ec.europa.eu/competition/consultations/2015_cmo_regulation/ep_agri_committee_annex_en.pdf

[471] Bukeviciute, L., Dierx, A. and Ilzkovitz, F., 2009. The functioning of the food supply chain and its effect on food prices in the European Union (No. 47). Office for Infrastructures and Logistics of the European Communities.

[472] European Commission, 2019. Cap Objective 3. Farmer position in value chains, Briefing note Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-3-farmer-position-in-value-chains_en.pdf

[473] https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-3-farmer-position-in-value-chains_en.pdf

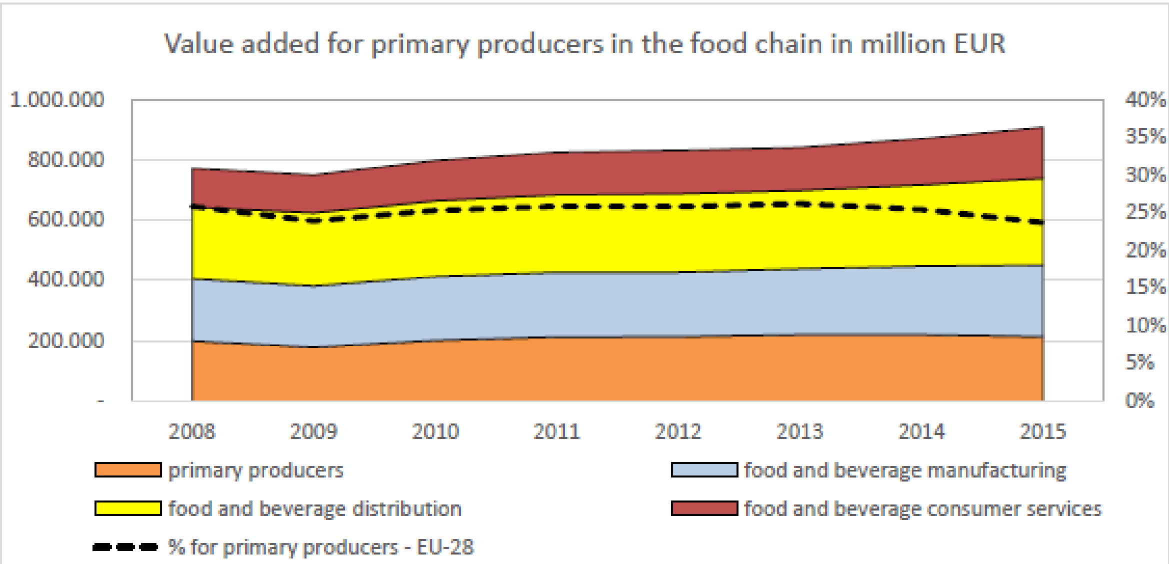
[474] EU Agricultural Markets Brief (2015), No. 4.Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/trade/documents/agri-market-brief-04_en.pdf

food retail and services sector; DG Agri, 2018[475]), effectively eroding the share of value added of agriculture.

According to the Commission's answer to a Parliamentary Question (E-000521/2015), although agricultural food production represents the largest number of businesses, its value added in the food chain dropped from 31% in 1995 to 21% in 2011. By contrast, the value added of the entire food industry was around 28% and for the food and retail services combined was 51% (van der Ploeg et al., 2016; EP, undated). Other sources[476] place the share of added value from agriculture in the food value chain (EU average) at around 25%, slightly declining in recent years including a 4% drop from 2014 to 2016[477] (see Figure 10.15; EC, 2019 below).

Huge disparities in the share of value added from agriculture are also reported between Member States, with their share of value added from agriculture ranging between 61% in Romanian and 9% in Luxembourg (see Figure 10.19; EC, 2019).

Figure 10.15. Value added in the food chain in million EUR – EU 28



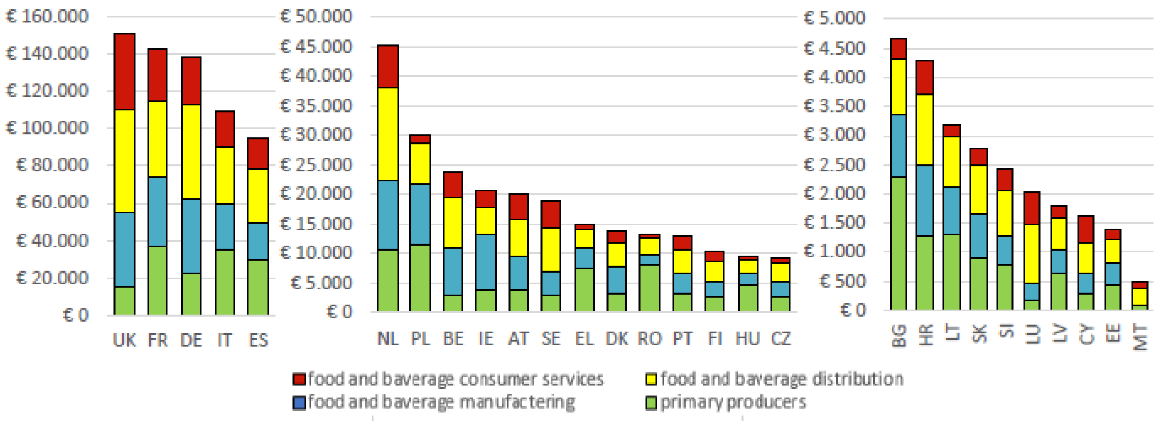
Source: DG AGRI based on Eurostat.

[475] Directorate-General for Agriculture and Rural Development, 2018. COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT Initiative to improve the food supply chain (unfair trading practices) Accompanying the document Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on unfair trading practices in business-to-business relationships in the food supply chain. Available at: https://ec.europa.eu/transparency/documents-register/detail?ref=SWD(2018)92&lang=en

[476] EC, 2019; DG Agri, 2018

[477] https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-3-farmer-position-in-value-chains_en.pdf

Figure 10.16. Value added in the food chain in million EUR – EU Member States



Source: DG AGRI based on Eurostat.

Differences in the share of value added for agriculture are also reported for alternative supply chains, as follows:

- The organic farming sector is characterised by continuous growth in response to increasing demand for more "natural" food and environmental concerns. For unprocessed foods in particular the share of price formation for organic farmers represents between 9% and 62% of the retail prices compared with 6%–40% in the conventional supply chain. However, whilst this difference indicates more value added is created in organic food, the price difference is not a true indication of the value added as it does not consider increased production costs[478].
- Short supply chains can increase the share of value added received by those businesses involved in the supply chain between the producer of the raw material and the final consumer and usually generates a higher employment multiplier than conventional food chains, in addition to delivering wider social benefits. The share of direct sales varies across Member States, ranging from 25% in Greece and less than 5% in Malta, Austria and Spain. In France, 21% of farmers sell their products within short supply chains, and half of those producing vegetables and honey are involved in Short Food Supply Chains[479].

Price transmission across the agri-food value chain

Though food represents a declining share of the household budget, food prices have been growing faster than prices for other goods following the 2007-2008 commodity price spike and economic crisis, driving up overall inflation[480].

Several factors contributed to the evolution of food prices: the increasing global demand for food due to population growth; the growing economic prosperity of developing economies and changes in dietary shifts away from grains to meats and other calorie-rich foods; the increasing demand for biofuels; the slowdown in productivity growth in agriculture (due to natural resources/land

[478] Sanders, J et al. (2016) Distribution of the added value in the organic food chain. Study for the European Commission. https://ec.europa.eu/agriculture/external-studies/2016-organic-food-chain_en)

[479] European Commission, 2019. Cap Objective 3. Farmer position in value chains, Briefing note Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-3-farmer-position-in-value-chains_en.pdf

[480] EU Agricultural Markets Brief (2015), No. 4.Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/trade/documents/agri-market-brief-04_en.pdf

constraints); the poor harvests in some major producing countries; as well as the increasing input cost (e.g. fertilisers, plant protection products) and their link with price trends in other commodities such as energy. Other factors, such as the existence of unfair trading practices (UTPs) in contractual relations, have an impact on the economic viability of those actors with weaker bargaining power in the food chain[481].

In some cases, prices show asymmetric transmission, where consumer prices rise in line with agricultural price spikes but a decrease in prices is transmitted more slowly to the subsequent stages of the supply chain when there is a downward price movement of raw materials (i.e., stickiness of prices). This asymmetric price transmission and the subsequent steady increase in consumer prices it causes (EU Agricultural Markets Brief, 2015), may be a result of differentiated market powers, although alternative explanations are also found in the literature (e.g., adjustment costs, menu costs, government intervention) and impacts can vary significantly across product type, level of the supply chain, seasonality and Member States[482]

The bargaining power of the retail grocery market in certain sectors is particularly noteworthy, given its potential impacts on producers and consumers. Power abuses from this sector can lead to additional costs to suppliers of particular products, with detrimental effects on worker's rights, environmental protection and the quality of the product/raw materials as producers attempt to reduce costs and remain profitable. Additional competition to suppliers from retailers' own brands compound to the pressure on suppliers and food producers. Whilst consumers benefit from lower prices in the short term due to deep discounting, the threat to suppliers' viability can lead price increases in the long term and impacts on the range and quality of products[483].

Resilience across the agri-food value chain

Demand for and supply of agricultural products is highly inelastic; even a small variation of quantity supplied or demanded can have a significant effect on prices. This makes the agricultural sector particularly exposed to demand and supply shocks, as a small reduction in demand or a small increase in supply can lead to a significant reduction in prices and, consequently, incomes (high income volatility).

Farmers are usually price-takers at the upstream end of the supply chains[484]. Their margins are determined by farm-gate prices and input costs, as both upstream farm input suppliers (e.g., PPP, fertiliser, seed and machinery suppliers) and processors and traders will be seeking to maximise their returns[485].

This pressure on farmers is compounded by the time lags between changes in market prices and production responses and the increasing complexity of global food value chains. The highly globalized and deregulated markets have introduced new and previously unknown levels of volatility (unpredictable price variation through time at every step of the food chain), which in turn create an insecure trading environment and contribute to higher price volatility and greater uncertainty (van der Ploe et al., 2016; DG Agri, 2018).

[481]DG Agri, 2018; EU Agricultural Markets Brief, 2015

[482] Such asymmetry was found to be more pronounced in food chains of the newer Member States when compared to the Euro area in 2009 and in specific sectors and countries.

[483] Nicholson, C. and Young, B., 2012. The relationship between supermarkets and suppliers: What are the implications for consumers. Consumers International, 1, pp.7-8.

[484]van der Ploe et al., 2016

[485] Rabobank, 2011. Rethinking The Food and Agribusiness Supply Chain; Impact of Agricultural Price Volatility on Sourcing Strategies.

Volatility is stronger for primary products. By contrast, downstream in the agri-food chain there tends to be a smoothening effect since (volatile-priced) raw materials represent only a limited share of the cost of the final food product. Consequently, consumer prices for food products tend to rise or decrease less than the raw material concerned (e.g., higher volatility of wheat prices than bread prices).

When time considerations are taken into account, short term volatility is more detrimental for the wholesale and processing stages, whereas long term fluctuations are harder to deal with for the farmers and retailers. In response to these pressures, for price changes that persist at least one year of production cycle farmers are more likely to adopt survival strategies aimed at minimising losses through long term output and cost reduction (e.g., reducing physical production and major investments, improving efficiency and diversification). Retailers on the other hand focus on securing a continuous supply of quality produce for their customers rather than reduce price volatility, whereas wholesalers and processors focus on adaptive strategies that secure stable margins regardless of price movements and are thus in a better position to deal with price volatility[486]. In turn, food security of consumers spending a large share of their income on food is also threatened by price volatility[487].

A notable finding of the Assefa et al (2017) study is the development in farmers' strategies to try to create added value through selection of better varieties to plant, production with less pesticide residues, product promotion, quality products marketed via labels, and collaboration with the retail sector to develop improved products. This was attributed to prices of premium products being perceived as more stable than standard quality products.

This argument feeds into a growing body of literature centred around the discussion of the influence of farm sizes on their overall economic viability and their ability to resist price shocks and increase value-added. Some authors maintain that large producers are best placed to obtain better deals from suppliers and customers and overtime there will be a shift to larger farms[488], whereas other authors argue that it is the large and quickly expanding farms that are the most fragile, especially when they are grounded on credit, and that small farms based on a self-owned and self-controlled resource base and managed according to a low-cost strategy increasingly represent resilience[489] (see e.g. van der Ploe et al., 2016; HLPE, 2019). The latter narrative argues what whilst there has been an increase in the average size of farms and a (gradual) disappearance of small farms in the aggregate level, this does not translate that small farms will necessarily be outcompeted and disappear, and that large farms will expand further. By contrast, small and medium farms make a far larger contribution to overall agricultural growth than larger farms, and small farms in particular should be treated as a promising category since many of them will be tomorrow's medium or even large farms. The mega-farms emerging in western and eastern Member States as well as the periphery (e.g. Maghreb, Ukraine, etc) are highlighted as a risk and there is a call for a redesigned of regulatory schemes and subsidies to stimulate patterns of growth and development at farm level that differ from mere quantitative enlargement, promoting in particular multifunctionality, quality production, on-farm processing, the construction of new markets that are 'nested' in new relations

[486] Assefa, T.T., Meuwissen, M.P. and Lansink, A.G.O., 2017. Price risk perceptions and management strategies in selected European food supply chains: An exploratory approach. NJAS-Wageningen Journal of Life Sciences, 80, pp.15-26.

[487] Hernandez, M.A., Ibarra, R. and Trupkin, D.R., 2014. How far do shocks move across borders? Examining volatility transmission in major agricultural futures markets. European Review of Agricultural Economics, 41(2), pp.301-325.

[488] HLPE. 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

[489] The authors argue that such low-cost farms are in line with societal needs (providing goods and service that have recently become scarce, and hence valued by society). They create employment, have the potential to deliver good income levels, help reduce fossil fuel use and are better positioned to engage in the protection of landscapes and biodiversity.

between producers and consumers and the (co-operative) protection of landscapes and biodiversity, as a model that favours social as well as economic sustainability (van der Ploe et al., 2016).

Increasingly, the impacts of environmental variability are not limited to local producers but spread through longer supply chains. For example, when a drought combined with rising biofuel demand, high oil prices, decreasing grain stocks and the depreciation of the US dollar, hit key grain-producing regions, the result was a spike in global grain prices that set off a series of rice export bans, furthering shortages and ultimately driving more than 130 million people into poverty and an additional 75 million people into malnourishment. Overall, the resilience of food supply chains to shocks (e.g. climatic event, environmental disturbance, price volatility) can be enhanced or hindered by private sector actors and is a function of its length and composition (e.g. globalised supply chain, short supply chain). However, little research has been conducted to examine the possibility of shock propagation, spill-overs and simultaneous shock events through food supply chains and their subsequent effect on consumption limiting the current understanding of the impact transmission in increasingly complex and globalized supply chains. Insights from resilience literature so far highlight the importance of production and source diversification and strengthening internal feedbacks[490].

A recent analysis of the disruptions to production, labour and transport during the COVID-19 pandemic have been shown to have asymmetric effects across the various actors of the value chain. Hohler and Lansik (2020)[491] showed particularly high volatilities in the stock prices of manufacturers of fertilizers and agrochemicals as well as food distributors and a low-price volatility in the stocks of food retailers, however their findings may not be representative of the overall impact on the small and medium size business of the supply chain.

Outlook in the 2020-2030 baseline

The performance of the agri-food value chain going forward will be strongly influenced by the evolving policy landscape and in particular the CAP, F2F and Biodiversity strategies, the continuous (re-) approval of active substances changing the availability of pesticides in different hazard categories (Regulation (EC) No 1107/2009) but also inter and intra EU trade as shaped by the scope and nature of the underpinning trade agreements. Other strong influences and pressures arise from changes in technology and society from e-food and convenience retail to food quality and safety[492], as well as increased climatic and environmental variability, and conflicting demand for/reduced availability of land use and resources. Furthermore, dietary shifts in the EU will also likely require a range of interventions with varying degree of influence and will require action across the whole supply chain, including changing consumer behaviour[493].

The challenges these movements present to agri-food firms foster competition and innovation, resulting in a series of inter-related markets in what is a continuously evolving and highly complex sector. One element of innovation within the agri-food sector is digitisation of the value chain, which is anticipated to disrupt the status quo by reducing information asymmetry through e.g., the emergence of on-line trading platforms for agricultural products, increasing transparency and traceability across the food value chain, creating an environment in which actors can more easily

[490] Davis, K.F., Downs, S. and Gephart, J.A., 2021. Towards food supply chain resilience to environmental shocks. Nature Food, 2(1), pp.54-65.

[491] Höhler, J. and Lansink, A.O., 2021. Measuring the impact of COVID-19 on stock prices and profits in the food supply chain. Agribusiness, 37(1), pp.171-186.

[492] https://www.europarl.europa.eu/RegData/etudes/STUD/2016/573428/IPOL_STU(2016)573428_EN.pdf

[493] Rust, N.A., Ridding, L., Ward, C., Clark, B., Kehoe, L., Dora, M., Whittingham, M.J., McGowan, P., Chaudhary, A., Reynolds, C.J. and Trivedy, C., 2020. How to transition to reduced-meat diets that benefit people and the planet. Science of the Total Environment, 718, p.137208.

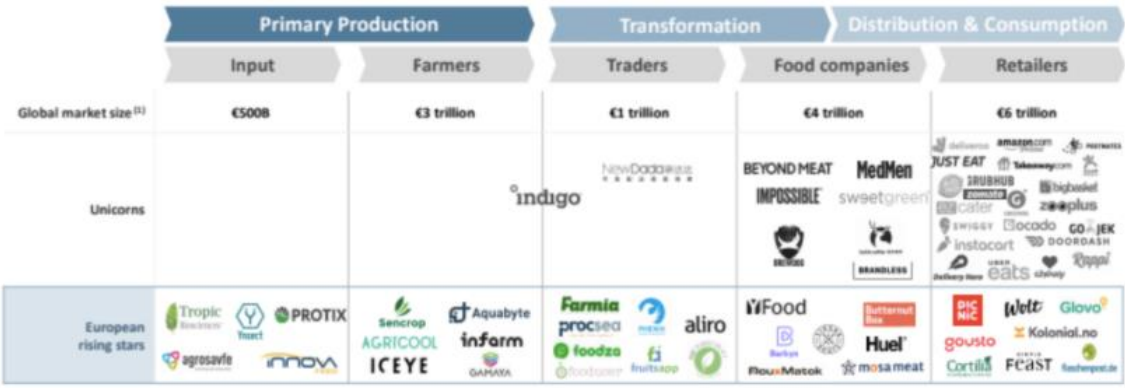
buy and sell, compare prices and review and rate suppliers. This transparency could also decrease margins for intermediaries and change distribution of value added across the food value chain[494]. With Europe's Food Tech companies representing almost 55% of the global AgriFoodTech ecosystem, the potential for disruption is high across areas ranging from food waste reduction to precision agriculture (see Figure 10.17 and Figure 10.18)[495][496]. However, the evolution of this sector over the baseline and its overall contribution to solving some of the key challenges of the agri-food sector, whilst material, is difficult to quantify.

Figure 10.17. Global AgriFoodTech start-ups funding split by category

	AG-TECH	CONSUMER APPS	FOOD DELIVERY	FOOD PROCESSING	FOOD SAFETY	NEXT-GEN FOOD & DRINKS	SMART APPLIANCE & KITCHEN	SURPLUS & WASTE
Total number of companies	650	488	427	100	107	475	292	150
Companies with funding activities available	220	105	140	31	41	108	91	44
Nb of investment rounds	403	162	316	59	77	190	117	69
Total Investment overtime	€3.83B	€3.3B	€11.9B	€997M	€247M	€2.3B	€593M	€284M

Data Source: Forward Fooding FoodTech Data Navigator (2009 - H1 2019)

Figure 10.18. Next generation of European rising stars innovating across the value chain



How the EU agri-food value chain deals with food waste is a critical component to the strategies' successes moving forward. Currently, the EU generated approximately 88 million tonnes of food

[494] Djaniana, M.I and Ferreria, N., 2020. Agriculture sector: Preparing for disruption in the food value chain. McKinsey

[495] https://forwardfooding.com/blog/foodtech-trends-and-insights/food-tech-trends-europe-2020/

[496] Forward Fooding, 2020. Looking forward at Foodtech 2020 & beyond. Foodtech data navigator.

waste annually, with associated costs of around EUR 143 billion[497]. Additionally, while the 20%[498] of EU food produced ending up lost or wasted is lower that the global average of ~33%[499], the fact that 33 million EU citizens cannot afford a quality meal every second day is concerning[500].

Food waste and losses along the value chain can be due to a number of factors: socioeconomic, biological (and/or microbiological), chemical or biochemical, mechanical and/or environmental[501]. Losses can be attributable to technologies, methods, techniques and practices employed by the food system's actors, while others can be related to natural causes – from pests and mould to environmental conditions[502].

Losses and waste are particularly important for specific goods such as fruit and vegetables. However, data and research findings on food loss and food waste are inconsistent[503].

- Whilst some authors attribute considerable potential to food losses and waste reduction at different stages of the food chain[504], others consider this potential to be overstated due to measurement problems[505]. Controversy is driven by the lack of a harmonized definition and methodology across Member States[506].
- Food losses and waste in the EU occur mainly at the distribution stage and, importantly, at the final consumption stages[507], with some estimates placing household consumption contribution to total waste around 53% and processing at 19%, with the production sector accounting for 11%. Whilst the potential to reduce consumer waste is large, the task is particularly challenging and requires a complex set of policies given the multiple root causes[508].

Despite the discrepancy around the actual figures, there is a general recognition that limiting food losses and waste could reduce the negative environmental impact of the food system and enable the use of more sustainable production techniques without displacement or leakage effects by reducing demand.

To combat food losses, the Commission is putting in action a plan to halve per capita food waste at retail and consumer levels by 2030 and reducing food losses along the food production and supply chains. Despite the challenges ahead, based on the above a degree of success in food waste and food loss reduction is considered in the baseline.

[497] http://www.eu-fusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf

[498] Vanham (2015) place this figure at 16%. Source: Vanham D., Bouraoui F., Leip A., Grizzetti B., Bidoglio G. (2015). Lost water and nitrogen resources due to EU consumer food waste. Environmental Research Letters, 10 (2015) 08408.

[499] http://www.fao.org/3/i2697e/i2697e.pdf

[500] https://ec.europa.eu/eurostat/data/database?node_code=ilc_mdes03

[501] http://www.fao.org/platform-food-loss-waste/resources/detail/en/c/1287928/

[502] https://mdpi-res.com/d_attachment/sustainability/sustainability-13-05443/article_deploy/sustainability-13-05443.pdf

[503] Guyomard, H., Bureau J.-C. et al. (2020), Research for AGRI Committee – The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU's natural resources. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

[504] Rutten M., Nowicki P., Bogaardt M.J., Aramyan L. (2013). Reducing Food Waste by Household and in Retail in the EU: A Prioritisation Using Economic, Land Use and Food Security Impacts. LEI report 2013-035, 156 p.

[505] Bellemare M. F., Çakir M., Peterson H. H., Novak L., Rudi J. (2017). On the Measurement of Food Waste. American Journal of Agricultural Economics, 9(5): 1148-1158.

[506] Britz W., Dudu H., Fusacchia I., Jafari Y., Roson R., Salvatici L., Sartori M. (2019). Economy-wide analysis of food waste reductions and related costs: A Global CGE analysis for the EU at NUTS-II Level. European Commission, Joint Research Centre (JRC) Technical Reports, September 2019, 85 p.

[507] Parfitt J., Barthel M., Macnaughton S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. Philosophical Transactions of the Royal Society B, Biological Sciences, 365: 3065-3081.

[508] Shanes K., Doberning K., Gözet D. (2018). Food waste matters - A systematic review of household food waste practices and their policy implications. Journal of Cleaner Production, 182: 978-991.

The extent to which the pressures and drivers listed will impact the performance of the agri-food value chain will differ for each tier and even within each tier, both at a Member State and EU level. The new CAP post-2020 will aim to address some of the challenges encountered by farmers and further bridge the value-added gap, however the extent to which it will succeed in reversing current trends and further counter environmental and economic pressures is uncertain, not least given the flexibility of implementation for Member States which may increase effectiveness but can also reinforce distributional differences. As previously mentioned, value added within each tier varies significantly across Member States and sectors, and farm size and overall business model play a critical role in the economic performance and overall resilience to shocks of holdings and enterprises. The characteristics of the value chains themselves (i.e., whether driven by a large retailer, large processor, specialized high quality retailer or large trader, short supply chains, or products with geographic indication) will determine the distribution of shocks across its various tiers. So, whilst this analysis focuses on the aggregate impacts, it is important to recognize that the impacts will be different for different actors within the same tier of the value chain depending on their business model and context.

10.2.4.2 *Impacts from achieving the pesticide-related targets announced in the F2F strategy*

Impacts on the food value chain arising from the food system transformation will be exacerbated by the new policy landscape. Those impacts are difficult to predict and challenging to untangle from the potential impacts of achieving the pesticide targets announced in the F2F strategy, not least given the high complexity and variability presented in the various types of agri-food value chains. The wider policy landscape will largely influence farm economics and value add share for each tier of the value chain and prices.

In a world in which demand for food, environmental and climatic variability and pressures on land and resources are expected to increase, farmers follow a preventive approach to pest management that typically sees a suite of management tactics being implemented prior to planting and in the absence of pest data. However, dependency on pesticide use (and thus, the economic impact of achieving the pesticide related targets announced in the F2F strategy) can be reduced trough technological development and an agricultural model that supports low-cost farms. Furthermore, such a model would likely see an increase in agricultural jobs and gross value add for agricultural producers.

A growing body of evidence is being put forward about the resilience of smaller farms and their inherent advantage in a future market in which price and demand/supply volatility is only expected to increase[509]. The acceleration of growth of mega-farms in recent years, supported by agricultural policies and income payments, has resulted in the appropriation and monopolisation of nearly all the ‘developmental space’ in the agricultural sector, blocking the development of small and medium farms. The very large farms have become favoured suppliers as they have enabled a reduction of transaction costs, at the exclusion of smaller producers that in some instances have been pushed out of the market[510]. However, far from disappearing, small farms (<5 ha) continue to represent two-thirds of the total farms and play an important role in reducing rural poverty and the provision

[509] By way of example, a review of the concentration in Italian agriculture conducted in the 90s showed a strong concentration of total Gross Value of Production (GVP) in the top decile of farms based on GVP/farm (“the eminent decile”). A more detailed analysis revealed that the farms in this category all had completely different characteristics (comprising both large, modernized farms as well as small farms) and the only featured they shared was being in the same statistical category. This was attributed to the capacity of small farmers to compensate for having a small farm by adopting organizational solutions that nonetheless allowed them to produce considerable revenues (van der Ploe et al., 2016).

[510] van der Ploeg, J.D., Ventura, F. and Milone, P., 2016. Research for Agri Commitee-Structural Change in EU Farming: How can the Cap Support a 21st Century European Model of Agriculture?: Research for Agri Commitee-Farm Structural Change in Western Europe and The CAP..

of income and food, with 96% of the farms in 2016 being classed as family farms. By contrast, the proportion of farms of 50ha or more is just 7%. Moreover, although the number of small and medium farms in EU has shown a decreasing trend, the official data should be treated with caution given the change in threshold for what is considered a farm in some countries has decreased statistical representation of the small holdings[511].

The literature suggests that the ability of farming systems to most effectively work with ecosystem services (from the recycling of biomass to the provision of pest control and pollination services) is closely linked to both farm size and landscape diversity. The promotion of greater visitation of pollinators to the crops of smallholder farmers (cultivating less than 2 ha) for example has shown median yield increases of 24%, as smaller farms' already high levels of biodiversity already support pollinator populations which then respond well to relatively simple measures (Garibaldi et al., 2016[512]). Fewer options are typically available to larger-scale farmers with larger fields. Ecological pest control (i.e. the process of restoring the balance between pests and their natural enemies (and movement barriers) through cultural techniques, promotion of farm biodiversity, choice of appropriate varieties and introduction of natural enemies) requires intimate farm knowledge and precise work organisation, both more common at smaller scales of operation. Similarly, sustaining soil health and fertility, using crop rotations and intercrops, cover crops and application of compose and organic manure are all also more common at smaller farm scales, due to typically greater labour intensities and more suitable organisations[513].

Overall, the literature shows that any economic impacts from achieving those targets would be more strongly felt by farmers, relative to other actors in the value chain, but transmission across the value chain is context specific and difficult to predict in the aggregate.

Across farmers, economic impacts from achieving the pesticide related targets announced in the F2F strategy will vary based on the size, productive orientation and location of farms. Social and environmental ambitions of the EU suggest a rethinking in the approach to farm concentration and growth, however the extent to which the new policies will support the development of smaller, low-cost farms or will continue to favour the accelerated growth of mega-farms is unclear.

Given the asymmetric transmission of impacts across the agri-food value chain and the ability of the food production and distribution/wholesale tiers to pass higher costs on to farmers and consumers, on average these actors are not anticipated to be significantly impacted by achieving the pesticide targets announced in the F2F strategy beyond the potential impacts on producer and wholesale prices. However, distribution impacts are noted, with impacts varying across and within tiers depending on the business model, context, and characteristics of the value chains.

10.2.4.3 *Conclusions regarding the agri-food value chain*

The table below presents an overview of the anticipated direction of change on the main economic indicators of the agri-food value chain resulting from achieving the pesticide targets announced in the F2F strategy relative to the baseline. Specifically, the baseline column in the table presents and

[511] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics#The_evolution_of_farms_and_farmland_from_2005_to_2016

[512] Garibaldi, L.A., Carvalheiro, L.G., Vaissière, B.E., Gemmill-Herren, B., Hipólito, J., Freitas, B.M., Ngo, H.T., Azzu, N., Sáez, A., Åström, J. and An, J., 2016. Mutually beneficial pollinator diversity and crop yield outcomes in small and large farms. *Science*, *351*(6271), pp.388-391. https://rid.unrn.edu.ar/bitstream/20.500.12049/3987/1/Garibaldi%20(2016)%20Mutually%20beneficial%20pollinator%20diversity%20and%20crop%20yield%20outcomes%20in%20small%20and%20large%20farms.pdf

[513] HLPE. 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

informed judgement on the direction of travel of the selected indicators over the 10 year period, based on the evidence base available and presented above. The second column presents an informed judgement on the additionality of SUD to those indicators, in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved. In this context, an upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator. The addition of e.g., a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD revision is expected to reinforce the baseline trends, whereas e.g., an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends. However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results.

Table 10-5. Anticipated impacts on selected indicators of the agri-food value chain

Indicators	Baseline	Pesticide related targets in F2F
Price volatility	↑	↑↑
Agricultural production		
• Number of holdings	↔?	↔?
• Size of farms	↓?	↓?
• Employment (FTE)	↔?	↔?
• Agricultural producer prices (at farm gate)	↑	↑↑?
• Value added	↑?	↑?
Food processing		
• Number of enterprises	↑	↑
• Employment (FTE)	↑	↑
• Domestic producer prices	↑	↑?
• Value added	↑	↑
Food distribution		
• Number of enterprises	↔	↔?
• Employment (FTE)	↑	↑
• Wholesale prices	↑	↑?
• Value added	↑	↑
Consumers		
• Number of consumers	↔	↔
• Consumer prices	↑	↑↑?

Note: anticipated trends depicted by arrows.
? denotes uncertainty in the projection

The trends in agricultural labour, farm number and size, producer prices and value add remain uncertain in the baseline given the evolving policy landscape and the lack of consensus and evidence base about its impacts. The extent to which the new CAP will reduce the erosion of the low-cost small farms is unclear, but the negative trend in the number of farms is expected to reduce based on the assumption of greater support for social and environmentally sustainable holdings. In particular, the anticipated decrease in the number of conventional farms is expected to be largely offset by the increase in organic farms.

Such development would in turn limit the decline in the volume of agricultural labour to some extent although gains are expected to be countered by greater mechanisation and efficiency in the sector. The average agricultural share of the value add could increase due to greater policy support, reinforced by a greater share of organic farming and short value chains. However, this gain will not be equally distributed across all actors in the agricultural production tier. In this scenario, changes induced by achieving the pesticide targets announced in the F2F strategy are expected to be limited. Although it could provide an advantage to small, lower input farms, it is not expected to have a significant impact on employment. The rate of increase of producer prices could be reinforced by a reduced and increasingly volatile supply exacerbated by a reduction in pesticide use (refer to section 10.2.2). The extent to which these supply pressures will be balanced out by a demand side measures (i.e. reduction of food loss and food waste) and more sustainable trade agreements (refer to section 10.2.5) is unclear.

The evolution of the food industry and distribution/wholesale indicators is not anticipated to be widely impacted by achieving the pesticide targets announced in the F2F strategy beyond the potential impacts on producer and wholesale prices. However, given the ability of these sectors to pass higher costs on to consumers, the latter could see the biggest share of the impact on food prices. In particular, retailer/supplier power can see an asymmetric transmission of costs to producers and, in the long term, consumers. Ultimately, the impact on consumers will be closely linked to the changes on crop type and yield in the aggregate (refer to section 10.2.2) along with wider impacts on the sustainability of supply arising from the concentration and subsequent bargaining power of the retail grocery market and the evolution of the trade balance (refer to section 10.2.5).

10.2.5 Trade impacts

10.2.5.1 *Estimation of the 2020 – 2030 baseline*

Trade balance

The dynamic baseline was informed by the 2020-2030 EU Agricultural Market Outlook (EC, 2020[514]) and the 2021 update of the JRC cumulative economic impact of trade agreements on EU agriculture[515]. It is acknowledged that the projections from these outlook reports are based on the OECD-FAO Agricultural Outlook 2020-2029, updated with more recent global macroeconomic and market data[516].

European (and especially Western European) economies were significantly impacted by the COVID-19 crisis. Resilient supply chains of the agricultural sector were able to limit its impact on food markets (EC,2020) but the post-COVID European food market landscape is expected to evolve, primarily strengthening attitudes towards sustainable (both with respect to local sourcing and climate impacts), organic and high-nutrition foods. These attitudes are reflected in recent EU policy orientation papers such as the European Green Deal and its associated F2F and BDS strategies

[514] EC (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels. Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2020-report_en.pdf

[515] Ferrari, E., Chatzopoulos, T., Dominguez, I.P., Boulanger, P., Boysen-Urban, K., Himics, M. and Mâ, R., 2021. Cumulative economic impact of trade agreements on EU agriculture: 2021 update (No. JRC123037). Joint Research Centre (Seville site).

[516] While the OECD-FAO Agricultural Outlook published in 2021 presents a more recent outlook for the baseline period, and has been used to inform the analysis as relevant, this update has not yet been incorporated into the EU Agricultural Market Outlook and the 2021 update of the JRC cumulative economic impact of trade agreements on EU agriculture. These statistics have been added for context without further modification.

which emphasises environmental and climate sustainability of European farms. However, while current outlooks for how agricultural trade is to develop between the EU27 Member States and their global trading partners do consider evolving consumer preferences and attitudes, the potential impacts of the F2F and BDS strategies on food production within the EU and on trade with non-EU countries are not incorporated in their analyses. In addition, the 2020-2030 EU Agricultural Market Outlook only considers current ratified free trade agreements (FTAs) and not those under development or in the process of being enforced.

The EU JRC Cumulative Economic Impact of Trade Agreements on EU Agriculture on the other hand, while also explicitly not considering impacts of the European Green Deal (and F2F), post-BREXIT trade friction and COVID-19 impacts, does provide a 2020-2030 outlook for existing FTAs. Analysis covers 12 agreements with nations (or nations groups such as Mercosur – Argentina, Brazil, Paraguay and Uruguay) which make up 13% and 34% of EU agri-food exports and imports, respectively (Ferrari et al., 2021).

Key trading partners and trends

As shown in Figure 10.19 below, a strong EU trade balance in agri-food goods over the decade is expected, owing to large increases in exports to the 12 FTA partners (+29%) in relation to imports, which are also expected to increase (+13%) under an "ambitious scenario" dictated by greater market access Ferrari et al., 2021). A "conservative scenario" also projects an increase, with +25% exports and +11% import increases on the baseline. Although substantial export opportunities are expected for wheat, the 12 FTA partners are not seen as a major destination for cereal crops. The main sectors driving export increases are dairy and pork products. Dairy and pork exports are expected to increase by up to 7.3% and 8.9% respectively (compared to domestic consumption increases of up to 0.8%), with Japan a primary destination. Producer prices are expected to marginally increase for both markets.

With regards to imports, EU imports of oilseeds and meals from the 12 FTA partners represent 60-73% of the total imports for the sector, vastly outweighing the share for other arable crops including wheat and fruit and vegetables. This proportional importance, driven by Mercosur and Indonesia in particular, is expected to be maintained at a stable level (refer to Figure 10.20, Ferrari et al., 2021).

One sector where implementation of the 12 FTAs is expected to increase the value is beef, with increases of up to 26% driven by Mercosur and Australia projected to reduce domestic production prices. Other, smaller import increases of up to 3.7% and 3.9% for sheep meat and rice markets respectively are also expected, bringing associated domestic production declines (refer to Figure 10.19, Ferrari et al., 2021). It is important to note however that these import increases do not take into account the environmentally conscious trends in dietary preferences suggested by the 2020-2030 EU Agricultural Market Outlook.

Figure 10.19 Changes in EU trade of agri-food products by commodities and scenarios (2030)

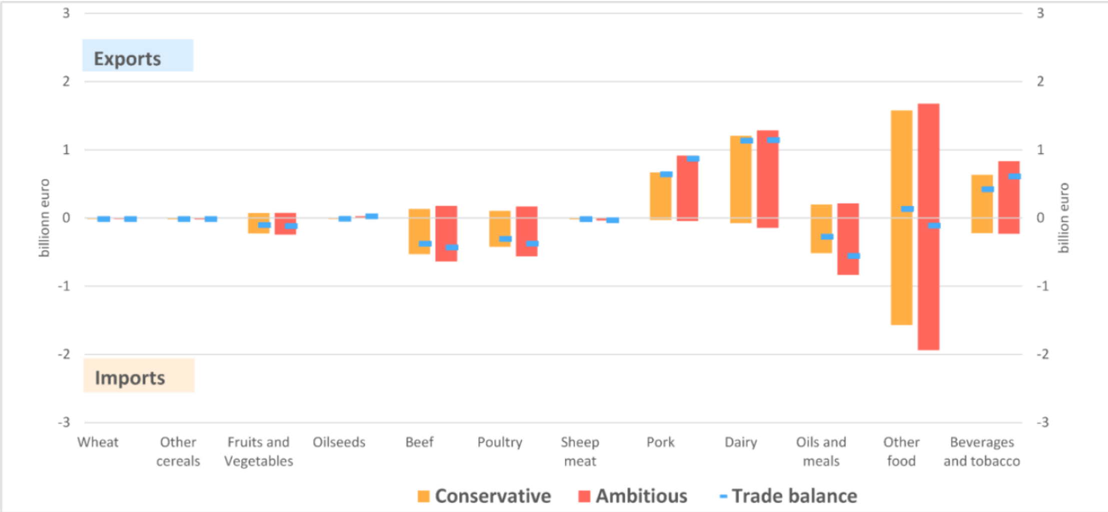
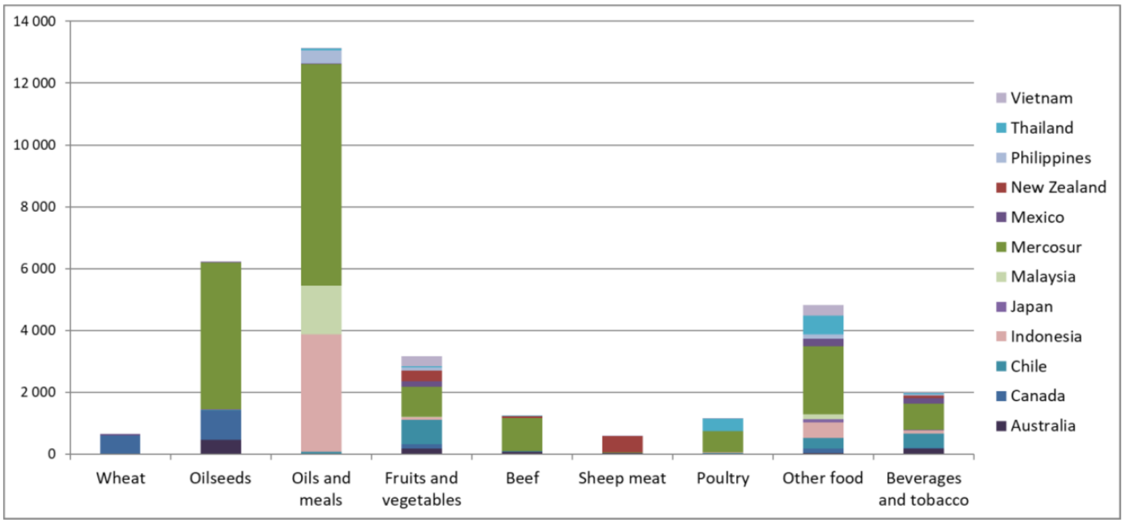


Figure 10.20 EU imports by products and trading partners (2030, EUR million)



However, these trends do not consider the impacts on yield, aggregate production and prices resulting from the current policy landscape, in particular impacts arising from the implementation of the F2F and biodiversity strategies, Green Deal and the new CAP (refer to section 10.2.2).

Before those environmental policies are considered, the JRC economic outlook suggest the following trends relative to a baseline without the new FTAs:

- EU exports of agri-food products are projected to increase due to increased trading opportunities – although arable crops are expected to maintain their current share of agri-food imports.
- EU imports are also expected to increase due to increased trading opportunities, however not at the same rate as exports, maintaining a strong EU trade balance. Arable crops are again expected to maintain their current share of imports, with oilseed and meals maintaining a particularly high proportion relative to domestic production.

- EU production is expected to remain largely stable, with declines in available arable cropland (due to increasing forest and pastureland) offset by improving yields due to digitisation and improved farming practices.
- EU producer and consumer prices are both expected to reduce, due to a combined effect of GDP, oil price and consumption shocks. Biofuel and feedstock markets are expected to be most impacted. Impacts on producer and consumer prices on non-EU countries are not explored.

Review of other relevant Impact Assessments

This section outlines the trade-related projections of the policy reviews and Impact Assessments discussed in section 10.2.2 for an overview of their respective scopes and projections on yield, crop area and food prices, please refer back to that section.

Analysis by the USDA[517] anticipates a diminishing in the competitiveness of EU farmers in domestic as well as export markets. The analysis, although heavily caveated by aforementioned limitations, concludes that proposed input reductions will lead to a reduction in EU agricultural food production by 7 to 12%, diminishing the competitiveness of EU farmers in domestic and export markets. Beyond the EU, the analysis expects worldwide food prices to increase by between 9 (EU only adoption) and 89% (global adoption), with food security impacts ranging between 22 million (EU only adoption) and 185 million (global adoption) people across 76 low and middle-income countries analysed. Moreover, the study anticipates a reduction in trade driven by production declines in the EU and elsewhere, with the impact being unequally distributed.

The JRC's recent report (Barreiro-Hurle et al, 2021[518]) also shows a decline in EU production. This decline, coupled with variations in prices and income for selected agricultural products, is predicted to lead to a decrease in net export positions for cereals and worsening in the EU trade deficit for oilseeds, fruits and vegetables. Producer prices show an increase in all four scenarios tested, however; overall revenues show a decrease due to higher costs.

COCERAL-PUNISTOCK's (2021[519]) study projects production decreases (ranging from 8%-38%) for all crops considered except for soyabean crops. In response to supply side constraints, the study argues that the EU would need to either increase its imports of grains or implement demand side measures to reduce consumption, with impacts as follows:

- The study anticipates a reduction in demand to have knock on effects on other sectors (e.g. livestock, oils, starch, biofuels, packaging activities for food and fuel produce) and to lead to higher price volatility. In addition, should the current trend in demand for organic products remain stable, the study projects a drop in organic food prices and an isolation of 25% of the EU production from the world market mechanism.
- An increase in imports would lead to a higher price level in EU and non- EU markets, which in turn would lead to higher costs for consumers as well as other actors in the value chain. The

[517] Beckman, Jayson, Maros Ivanic, Jeremy L. Jelliffe, Felix G. Baquedano, and Sara G. Scott. November 2020. Economic and Food Security Impacts of Agricultural Input Reduction Under the European Union Green Deal's Farm to Fork and Biodiversity Strategies, EB-30, U.S. Department of Agriculture, Economic Research Service.

[518] Barreiro-Hurle, J., Bogonos, M., Himics, M., Hristov, J., Pérez-Domiguez, I., Sahoo, A., Salputra, G., Weiss, F., Baldoni, E., Elleby, C. Modelling environmental and climate ambition in the agricultural sector with the CAPRI model. Exploring the potential effects of selected Farm to Fork and Biodiversity strategies targets in the framework of the 2030 Climate targets and the post 2020 Common Agricultural Policy, EUR 30317 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-20889-1, doi:10.2760/98160, JRC121368.

[519] COCERAL-UNISTOCK, 2021. Impact of the Farm to Fork targets on the Cereals and Oilseeds markets. COCERA-UNISTOCK's main findings. Available at: https://nofota.com/wp-content/uploads/20210525_COCERAL-UNISTOCK_Impact_of_the_Farm_to_Fork_final_210521-1.pdf

EU would become a net importer, putting additional pressure in other countries to increase their total agricultural land to meet demand, and increasing transport cost. Coupled with additional demand driven by population growth, food/fuel security and prices are raised as a key concern. Import Tariff-Rate Quotas regulation in particular is highlighted as a constraint that would raise costs if unmodified.

As mentioned in section 10.2.2, results of the Impact Assessment Study on EC 2030 Green Deal Targets for Sustainable Food Production (currently being conducted by Wageningen University and Research on behalf of CropLife Europe) are partial and preliminary and must be caveated until the full report is available. A high-level assessment of the analysis however does suggest likely impacts on the EU trade balance as result of reduced yields, and losses in production due to yield and quality losses which may be partly counteracted by increase in prices driven by resource 'scarcity'.

Overview of direct trade impacts

Whilst none of the studies reviewed are conclusive, and none of them evaluates the impact of achieving the pesticide related targets announced in the F2F strategy in isolation, they all point to potential impacts on the trade balance from increased dependency on imports (e.g. cereals, oilseeds) and a decline in exports (e.g. wheat, and specialised crops such as olives and wine).

Notably, from the information available these policy reviews and impact assessments do not appear to incorporate demand side measures, nor some of the concluded but not implemented recent free trade agreements with the EU (e.g. with Mercosur and the updated FTA with Mexico, as well as trade agreements under negotiation (Australia, Indonesia, Malaysia, New Zealand, the Philippines, and Thailand) or the modernisation of the agreement with Chile. These agreements are expected to provide new trading opportunities and strengthen the trade balance and may counteract some of the impacts on trade from the Green Deal, F2F and Biodiversity Strategy. At the same time, the JRC trade outlook (Ferrari et al., 2021) does not consider the potential impacts of the F2F, Green Deal and Biodiversity Strategies in its trade growth projections.

As outlined above, the JRC trade outlook predicts EU producer and consumer prices to reduce, while the impact assessments investigating the F2F, Gren Deal and Biodiversity Strategies predict increases in price (globally) driven by the lower availability of certain crops. Any changes in food prices could have impacts on food availability and nutrition, with disproportionate effects on developing economies as well as significant distributional effects within the EU (see section 10.2.4).

The extent to which the positive and negative trends will balance out is very difficult to predict based on current knowledge in the absence of robust evidence base, and the risks will be very much dependent on the different times at which each FTA will be ratified and will be definitively enforced, as well as on the nature and timescales of implementation of supplementary policies targeting demand side reductions, and any additional measures targeting coordination, knowledge transfer and capacity building in non-EU countries and in particular developing economies.

Integrated approach: economic, environmental and social implications of trade and its distributional effects

Total import of agricultural products in the EU, in physical terms, is greater than that of total export (Eurostat, 2021[520]). This reliance on trade has led to a considerable externalisation of environmental pressures, and a dependence on ecosystem services located outside of EU MS's respective national boundaries (Renner et al., 2020). Tensions among environmental and economic objectives in the EU policy are one of the drivers of evolution in the EU agricultural sector towards outsourcing of

[520]Eurostat, 2021. International trade in goods database. Available at: https://ec.europa.eu/eurostat/web/international-trade-in-goods/data/database

commodity production through trade. By outsourcing low-value commodity production (e.g. animal feed), the EU agriculture has been able to focus its activities on high-value product chains (Cadillo-Benalcazar et al., 2020[521]; Wang et al, 2018[522]). Thus, the trade balance has important environmental and human health implications on the distribution of impacts on biodiversity and on the integrity of EU ecosystems, as well as on the ecosystems of non-EU trade partners. By way of example, Cadillo-Benalcazar et al., (2020) have estimated the percentage mass of pesticides displaced due to the import of agricultural products to exceed the amount currently used in the EU.

The achievement of the pesticide reduction targets announced in the F2F strategy therefore is inextricably linked to the evolution of trade in agricultural commodities. A direct or indirect reduction of pesticide use and risk in non-EU exporting countries – whilst limiting the externalisation or leakage of environmental impacts – could lead to unintended economic and social consequences in exporting nations of reduced farm productivity, particularly in the face of increasing risks of shock events in developing economies. To bring the current level of externalisation of environmental impacts from agricultural production into context, the first part of this section explores the anticipated impacts in the EU of a potential partial re-internalisation of its agricultural production driven by the increasing global competition for food. The second part of this section explores the risks and trade-offs associated to a direct or indirect reduction in pesticide use in non-EU countries.

The cost of re-internalising agricultural production and the role of trade in optimising land use and mitigating environmental externalities

In the absence of global environmental standards, global competition for food, driven by a projected 60% increase in global food demand by 2050 (Alexandratos and Bruinsma, 2012[523]) could further deteriorate environmental quality in exporting countries. Exacerbated by resource shortage, environmental deterioration and political turmoil, this global competition could reduce the availability of cheap food imports and pose a risk to EU food security, putting pressure on the EU to re-internalise some of its agricultural production Renner et al., 2020[524], Cadillo-Benalcazar et al., 2020).

Dependence on import for animal feed and vegetable products (based on physical quantities) varies across Member States. Cadillo Benalcazar et al. (2020) have estimated the self-sufficiency in vegetable products to be higher in countries like Poland and France (above 80%), with the level of self-sufficiency in most South Eastern and North Eastern countries estimated to be great than 50%, going down to under 30% in countries like the Netherlands and Norway. Furthermore, when considering animal feed, all EU countries except Ireland have a self-sufficiency rate lower than 30%. Therefore, re-internalisation of food production would have significant environmental and social impacts and their distributional effects across the EU Member States would be unequally felt.

Renner et al., 2020 explored the impacts that a theoretical (and unlikely) 90% re-internalisation by each of the 27 EU Member States - plus the UK and Norway - would have on labour, land use and blue water use in the EU. Pressure on water resources would more than double in all the 29 countries, whereas 26 out of the 29 were anticipated to require more than 100% of their currently available agricultural land, often considerably more, together with an increase in inputs including

[521] Cadillo-Benalcazar, J.J., Renner, A. and Giampietro, M., 2020. A multiscale integrated analysis of the factors characterizing the sustainability of food systems in Europe. Journal of Environmental Management, 271, p.110944.

[522] Wang, J., Liu, Q., Hou, Y., Qin, W., Lesschen, J.P., Zhang, F. and Oenema, O., 2018. International trade of animal feed: its relationships with livestock density and N and P balances at country level. Nutrient cycling in agroecosystems, 110(1), pp.197-211.

[523] Alexandratos, N., Bruinsma, J., 2012. World Agriculture Towards 2030/2050: The 2012 Revision. Rome.

[524] Renner, A., Cadillo-Benalcazar, J.J., Benini, L. and Giampietro, M., 2020. Environmental pressure of the European agricultural system: Anticipating the biophysical consequences of internalization. Ecosystem Services, 46, p.101195.

PPP. Thus, 3-4x land use and water efficiency would be needed on average, when current and foreseeable technological development rates are taken into account. Greater pressure on land is anticipated in highly urbanised countries such as France and the UK, and countries with a relatively low percentage of agricultural land and a relatively high level of imports, such as Austria. Impacts associated with the increasing need for water abstraction for irrigation would be particularly acute in some Mediterranean regions, given the mixture of arid climate and high levels of irrigation, which in certain agrarian provinces have already led to critical freshwater over-exploitation. In addition, the 2-3x increase in human activity in the agricultural sector (hours of labour per capita per year) in the event of near-complete re-internalization effort would be a significant economic constraint, given that the agricultural sector generates a lower economic return than other economic sectors. Farmers receive around 40% less income than workers in other sectors, a situation in turn motivating the CAP to further support the economic viability of farmers (EU Commission, 2021[525]; Cadillo_Benalcazar et al., 2020).

There is also a question around the role of trade in optimizing the mix in the origin of consumed commodities (i.e. by sourcing products from regions where land resources are used more efficiently; Roux et al., 2021[526]), with studies suggesting that e.g. international trade improved 9 SDG indicators relative to a hypothetical non-trade scenario (Xu et al., 2020[527]), and that trade reduces global cropland area by 8% (Kastner et al, 2014[528]). Whilst international trade mostly reduced human pressures on land in the 1990s, Roux et al. (2021) argue that changes in interregional trade have cancelled out benefits from intraregional trade from the late 1990s and outweighed them from the mid-2000s, particularly due to the acceleration of exports from tropical regions (e.g. South America and South East Asia) to Europe and Asia since the tropics present higher impact on terrestrial ecosystems per unit of product than temperate regions (Wes et al., 2010[529]). This suggests that on average, trade liberalisation efforts have not succeeded in enhancing trade in those geographies that would have supported an increase in the efficiency of land use, and have often exacerbated trade flows that increased pressure on land ecosystems and in particular in the tropical regions (Roux et al., 2021).

Anticipated climate change impacts on agricultural production and trade are a key driver that deserves further attention when considering trade optimization and leakage reduction. Porfirio et al (2018)[530] suggest that centralisation of the global agricultural trade network may be correlated with levels of global CO_2 emissions over the coming decades, due to the less distributed structure of the network increasing resilience to climatic effects.

Consequently, what commodities are traded (in turn dependent on changes to the aggregate agricultural production and food prices, refer to section 10.2.2) and where and how they are produced (influenced by market demand, environmental and climatic conditions, the impact of non-technical barriers to trade and trade agreements, amongst other) will ultimately determine the

[525] European Commission, 2021. The common agricultural policy at a glance. Available at: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en [Accessed 13 August 2021]

[526] Roux, N., Kastner, T., Erb, K.H. and Haberl, H., 2021. Does agricultural trade reduce pressure on land ecosystems? Decomposing drivers of the embodied human appropriation of net primary production. Ecological Economics, 181, p.106915.

[527] Xu, Z., Li, Y., Chau, S.N., Dietz, T., Li, C., Wan, L., Zhang, J., Zhang, L., Li, Y., Chung, M.G. and Liu, J., 2020. Impacts of international trade on global sustainable development. Nature Sustainability, 3(11), pp.964-971.

[528] Kastner, T., Erb, K.H. and Haberl, H., 2014. Rapid growth in agricultural trade: effects on global area efficiency and the role of management. Environmental Research Letters, 9(3), p.034015.

[529] West, P.C., Gibbs, H.K., Monfreda, C., Wagner, J., Barford, C.C., Carpenter, S.R. and Foley, J.A., 2010. Trading carbon for food: Global comparison of carbon stocks vs. crop yields on agricultural land. Proceedings of the National Academy of Sciences, 107(46), pp.19645-19648.

[530] Porfirio, L.L., Newth, D., Finnigan, J.J. and Cai, Y., 2018. Economic shifts in agricultural production and trade due to climate change. *Palgrave Communications*, *4*(1), pp.1-9.

internalised and externalised environmental impacts associated with food production (e.g. land use requirements, productivity, PPP and other input requirements, water demand, labour requirements).

Trade-offs associated with a reduction in pesticide use in non-EU countries

Information gathered through stakeholder engagement: Focus Group on Trade

Direct or indirect restrictions on pesticide use and risk for the EU trading partners, with a particular focus on developing economies, were discussed during the Third Focus Group (conducted on 7th of July 2021, refer to Appendix 2).

The experts noted that experience from organic farming and some studies in France indicate that achieving the pesticide target announced in the F2F strategy may be achievable without large impacts on productivity, and questioned the actual impact on production after consideration of:

- Technical development
- Consumer/demand side measures
- Cultural changes in farmers/responsibility

However, in relation to non-EU countries, strong concerns were expressed about potential impacts on developing nations from reduced trade and, in particular, through direct or indirect restrictions on pesticide use resulting from the broader global sustainability ambitions expressed by the EU to avoid leakage. These could stem from more stringent MRL, or be imposed through market mechanisms (e.g. global supply chains will in time require producers in other countries to adopt EU standards, as has happened with biotechnology).

Such development would produce winners (those who can easily adapt at relative low cost or who can pass on the costs/retain their margins) and losers (those that have no low-cost alternatives and face a choice between trade barriers or lower yields). Smallholder production is inherently low input and more IPM aligned, and particular support is needed to avoid a disproportional impact on them. Thus, stakeholders stressed the challenges and limitations of looking at global impacts, as lack of granularity does not allow for the assessment of distributional impacts across countries, population segments, crops, etc.

Overall, the experts posed that environmental and human health benefits driven by a reduction in pesticide use and risk in third countries promoted by the EU would have economic and human health trade-offs due to consequences on agricultural production, farm revenue, food prices, and trade balance (increased dependence on imports and reduced revenue from exports in third countries), with knock on impacts on food security and nutrition. Supporting policies and instruments developed in the EU to compensate for and to minimise the reduction in supply, and in particular economic policies to support the transition, are not expected to be replicated in third countries. Therefore, the general view was that any negative impacts from a reduction in pesticide use and risk would be larger for non-EU producers than for EU producers, and could limit the availability of agricultural produce for export in non-EU countries.

Hence the group stressed the need for the EU to support the transition in non-EU countries by:

- Developing low-cost PPP alternatives (e.g. biocontrol) to any substance phased out, and promoting the availability and use of those alternatives in non-EU countries.
- Sharing knowledge, specifically with regards to agronomic practices and alternative pest control methods to support IPM implementation. Together with technological development, all these developments will be closely followed by other countries (e.g. in the global south) and could go a long way to support the transition outside of the EU. However, given that IPM is highly context

specific, substantial research is needed to develop local, context specific and effective strategies.

- Allowing reasonable time periods for adaptation to achieve the necessary productivity increases. In particular, the timeframe covered in the analysis was also called into question, given the pace of development, and the times involved in the registration and marketing of new substances, and a suggestion was made for impacts beyond 2030 to be considered.

Pesticide impacts in developing countries

The report on the use of pesticides in developing countries and their impact on health and the right to food, recently published by DG for External Policies (Sarkar et al., 2021)[531], stresses that pesticides provide the only form of crop insurance available in some developing countries, particularly when considering the uncertainties posed by changeable weather conditions driven by climate change on crop yields and the economic impacts on farmers from the COVID-19 pandemic, which has pushed up cost for farmers and reduced income.

Pesticide demand and use is increasing in many developing countries which together account for a quarter of global pesticide use (UNICEF, 2018[532]; FAOSTAT, 2021[533]). Increased usage can be driven by strong food demand in developing nations, expansion of production and of export markets, changing opportunity costs for labour, or pests, with emergency situations sometimes leading to strong increases in pesticide use.

The key findings of the Sarkar et al., (2021) on the use of pesticides in developing countries and their impact on health and the right to food are summarised here:

- Export of PPP banned from use within the EU is possible, with the four main current destinations being in Latin America (led by Brazil). Less than 5% of pesticide sales currently go to Africa although their use is growing sharply driven by the arrival of new crop pests, particularly in West Africa. Health concerns associated with the handling and use of PPP are typically greater in developing countries due to the lower use of personal protective equipment, inadequate use due to the inability of farmers to read the instructions, lack of training on pesticide use, and inappropriate storage. The use of IPM, while promoted by the FAO and the EU, has been attempted by a number of countries, most notably Indonesia, but the level of support required has been difficult to maintain due to its complexity and the resistance posed by farmers. Shocks from climate events and pandemics and challenges presented by the alternatives, together with the lack of business incentives or regulatory requirements for PPP manufacturers to make changes to their product portfolios, have further hindered the shift. Enhanced regulation and enforcement in developed as well as developing countries are proposed as the means to encourage the shift to alternatives, however, constraints from a slow regulatory approval process, economic competitiveness of older, more harmful products and the influx of counterfeit imports and illegal mix and sale of local variants of pesticides for sale at affordable prices to small farmers are highlighted.
- The shift to alternatives over the coming years will be insufficient to eliminate the use of chemical pesticides without compromising food security and clearer, more consequential

[531] Sarkar, S., Gil, J.D.B., Keeley, J. and Jansen, K., 2021. The use of pesticides in developing countries and their impact on health and the right to food. European Union. Available at: https://www.europarl.europa.eu/thinktank/en/document.html?reference=EXPO_STU(2021)653622

[532] United Nations Children's Fund (UNICEF), Understanding the Impacts of Pesticides on Children: A discussion paper, 2018. Available at: https://sites.unicef.org/csr/files/Understanding_the_impact_of_pesticides_on_children-_Jan_2018.pdf

[533] Food and Agriculture Organization Corporate Statistical Database (FAOSTAT), 2021. Pesticides Use. Available at: http://www.fao.org/faostat/en/#data/RP/visualize

differentiation among different types of pesticides will be required through leadership from the EU in regulation and enforcement and multilateral cooperation for the standardisation of metrics and approaches on pesticide restrictions will be needed to consolidate a new approach to food security (e.g. stop all exports of crop control products banned in the EU, restrict the export of severely restricted pesticides to those regulated accordingly and properly used in the importing country and support in establishing an efficient pesticide re-evaluation process in developing countries). Communication, awareness raising and knowledge sharing on the hazards associated to pesticides and benefits and use of alternatives will be instrumental, supported by other policies such as promoting the widespread adoption of digital technologies that enable better product tracing, encouraging private sector investment in sustainability, strengthening research on agroecology, organic farming and IPM along with knowledge sharing in developing countries.

The link between trade balance and nutrition

The number of people affected by hunger globally has been slowly on the rise since 2014, with the majority of the world's approximately 690 million undernourished still found in Asia (381 million). More than 250 million are undernourished in Africa, where the number is growing faster than in any other region in the world. The number of people affected by severe food insecurity (750 million) also shows an upward trend, with an estimated 2 billion people in the world affected by moderate or severe levels of food insecurity, and the word is not on track to achieve Zero Hunger by 2030 – a recent estimate predicts the number of undernourished people will exceed 840 million by 2030. COVID-19 is expected to worsen the overall prospects for food security and nutrition, and pockets of food insecurity may appear in countries and populations groups that were not traditionally affected; preliminary estimates suggested the COVID-19 pandemic was on course to add an additional 83 to 132 million undernourished people in 2020. The expected recovery in 2021 would bring the number of undernourished down, but still above what was projected pre-pandemic (FAO, 2020[534]; FAO SOFI, 2021,[535]).

Food insecurity can affect the quality of the diet and lead to undernutrition as well as weight gain and obesity, and diet quality has been found to worsen as the severity of food insecurity increases. Cost and affordability of nutritious foods are a key factor affecting food security and diet quality, with healthy diets costing 60% more than diets that only meet the requirements for essential nutrients and almost 5 times as much as diets that meet only the dietary energy needs through a starchy staple. Most of the people who cannot afford healthy diets live in Asia (1.9 billion) and Africa (965 million), followed by Latin America and the Caribbean (104.2 million), with the fewest in Northern America and Europe (18 million). Addressing a problem of this magnitude requires a food systems transformation worldwide. Key drivers of the cost of a healthy diet, particularly in low-income countries, are low levels of productivity, high production risks and insufficient diversification towards the production of more nutritious foods (FAO, 2020).

Countries affected by conflict, climate extremes or economic downturns, or with high inequality, are most at risk of hunger. Trade can improve the availability and diversity of nutritious food, but it can also increase the availability, accessibility and affordability of highly processed foods.

[534] FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Rome, FAO. https://doi.org/10.4060/ca9692en

[535] FAO, IFAD, UNICEF, WFP and WHO (SOFI). 2021. The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome, FAO. https://books.google.co.uk/books?hl=en&lr=&id=09zyDwAAQBAJ&oi=fnd&pg=PR1&dq=The+State+of+Food+Security+and+Nutrition+in+the+World+2021.+Transforming+food+systems+for+food+security,+improved+nutrition+and+affordable+healthy+diets+for+all&ots=WLeh7ony6t&sig=72TEK6W-xbmvoGH24pPxXkagWQQ&redir_esc=y#v=onepage&q&f=false

Many countries with low nutrient adequacy rely upon a few major trade partners with imports dominated by cereals rather than micronutrient-rich food products. Trade policies, mainly protectionary trade measures and input subsidy programmes, tend to protect and incentivize the domestic production of staple foods, such as rice and maize, often at the detriment of nutritious foods, like fruits and vegetables. Coherence between trade and nutrition policies, along with nutrition-sensitive production policies, are required to reduce these risks, and non-tariff trade measures can help improve food safety, quality standards and the nutritional value of food, and minimize any unintended consequences of trade. However, they can also drive up the costs of trade and hence food prices, negatively affecting the affordability of healthy diets and in turn leading to food insecurity and malnutrition (FAO SOFI, 2021[536]; Geyik et al., 2021[537]; FAO, 2020).

Overview of trade-offs in a complex, multi-dimensional food system

Environmental pressures posed by the EU either through internal agricultural production or through trade in agricultural products are inexorably interlinked with the caloric intake and dietary profiles of its population (i.e. food availability and cultural factors). Thus, changes in consumption patterns can go a long way to reduce internal and externalised environmental pressures. For example, a dietary or policy driven reduction in meat consumption would reduce dependence on imports and/or the environmental pressures from the potential need to re-internalise some animal feed production (in addition to reducing GHG emissions), but would in turn have economic consequences for the EU producers of animal products (Cadillo-Benalcazar et al., 2020). On the other hand, and as previously discussed, higher costs for EU producers resulting from the implementation of the Green Deal, F2F and Biodiversity strategies could erode the competitiveness of EU-farming and the agri-food sector, deterring EU exports (Bryan, 2020[538]). This has led to concerns about the level playing field for EU farmers and has driven calls for the application of the reciprocity principle to agri-food products from third countries, to ensure they have not been treated with PPP that are not authorised on the European single market (Roche Ramo, 2021[539]). In turn, these measures would also have social and economic consequences in the exporting countries through the potential deterioration of food prices and food availability, with negative impacts on the Sustainable Development Goals set out by the UN Agenda 2030. In response to these multi-dimensional and interlinked challenges and complexities, the European Economic and Social Committee has called for a more sustainable food policy with the aim of "providing healthy diets from sustainable food systems, linking agriculture to nutrition and ecosystem services, and supply chains which safeguard public health for all sections of European society" (EESC, 2018)[540].

[536] FAO, IFAD, UNICEF, WFP and WHO (SOFI). 2021. The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome, FAO. https://books.google.co.uk/books?hl=en&lr=&id=09zyDwAAQBAJ&oi=fnd&pg=PR1&dq=The+State+of+Food+Security+and+Nutrition+in+the+World+2021.+Transforming+food+systems+for+food+security,+improved+nutrition+and+affordable+healthy+diets+for+all&ots=WLeh7ony6t&sig=72TEK6W-xbmvoGH24pPxXkagWQQ&redir_esc=y#v=onepage&q&f=false

[537] Geyik, O., Hadjikakou, M., Karapinar, B. and Bryan, B.A., 2021. Does global food trade close the dietary nutrient gap for the world's poorest nations?. Global Food Security, 28, p.100490.

[538] Bryan, John, 2020. Compatibility of EU trade policy with the European Green Deal. NAT/791-EESC-2020-EESC-2020-01349. Plenary session 554, Sep 16 – Sep 18, 2020. Available at: https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/compatibility-eu-trade-policy-european-green-deal-own-initiative-opinion

[539] Roche Ramo Jose Manuel, 2021. Evaluation on Directive on the Sustainable use of Pesticides (Information Report), Plenary session 560, Apr 27 – Apr 28 2021. Available at: https://www.eesc.europa.eu/en/our-work/opinions-information-reports/information-reports/evaluation-directive-sustainable-use-pesticides-information-report

[540] EESC opinion on The Civil society's contribution to the development of a comprehensive food policy in the EU, OJ C 129, 11.04.2018, p. 18.

The above exemplifies the clear impact of food trade on pesticide use and the trade-offs between EU and non-EU agricultural production. To address these challenges and their associated economic, environmental and social impacts, it is imperative to integrate the Green Deal, F2F, Biodiversity and climate strategies along with the SDG goals into trade policies. Trade agreements and demand side measures can play an important role in reducing some key environmental and social pressures from agriculture, but they need to be balanced against social and economic impacts both within the EU and for its trading partners, and integrated as part of a sustainable food system. In addition, the role of trade in reducing vulnerability to climatic or institutional shocks (through a more distributed trade and production network) to reduce food insecurity[541] should be considered.

Until green recovery and environmental considerations are more closely integrated with trade policies, land use changes resulting from demand pressures along with biodiversity degradation on non-EU countries are anticipated to continue a downward trend in the baseline. Similarly, pesticide use in expected to continue to grow across most EU-exporting countries in the baseline.

10.2.5.2 *Impacts from achieving the Pesticide-related targets announced in the F2F strategy*

This section explores the trade related impacts arising from the food system transformation which are expected to be spurred on by achieving the pesticide targets announced in the F2F strategy.

The diminishing effect of additional regulatory requirements on trade is well documented in the literature (e.g. Nabeshima et al., 2021[542]; Nabeshima and Obashi, 2021[543]; Fontagné et al., 2015[544]), with non-tariff measures having a disproportionate effect on developing countries and smaller firms. A key factor is the difference between the regulations in the exporting and the importing country, with the real impact arising from ‘additional’ requirements not imposed in the exporting country but with which the exporters need to comply. Within a particular sector of the destination market country, Nabeshima et al., (2021), found that a country facing more regulatory burdens exports a narrower set of goods (i.e. extensive margin) and lower quantities of each good at higher prices (i.e. the intensive margin). In particular, trade-diminishing effects of additional compliance requirements in exports from developing nations to advanced economies were found to be twice as large in magnitude for agricultural sectors than for manufacturing sectors, and were also relatively large when decomposed into its intensive and extensive margins (see definitions above):

- Non-tariff barriers, rather than tariffs, are substantial obstacles faced by the agricultural exporters of developing nations trading with advanced economies.
- Agricultural exporters from developing nations to advanced economies appear to face greater cost burden on average, to comply with the same degree of additional requirements than manufacturing exporters.
- International policy cooperation appears to enhance trade in agricultural goods through the information cost-saving effect, countering the compliance cost raising effect.
- Agricultural exporters from developing nations to advanced economies are not differentiating export prices across destination countries with respect to the regulatory burden imposed by those countries.

[541] Porfirio, L.L., Newth, D., Finnigan, J.J. and Cai, Y., 2018. Economic shifts in agricultural production and trade due to climate change. Palgrave Communications, 4(1), pp.1-9.

[542] Nabeshima, K., Obashi, A. and Kim, K., 2021. Impacts of additional compliance requirements of regulations on the margins of trade. Japan and the World Economy, 59, p.101088.

[543] Nabeshima, K. and Obashi, A., 2021. Impact of Regulatory Burdens on International Trade. Journal of the Japanese and International Economies, 59, p.101120.

[544] Fontagné, L., Orefice, G., Piermartini, R., Rocha, N., 2015. Product standards and margins of trade: firm-level evidence. J. Int. Econ. 97 (1), 29–44.

- The overall trade diminishing effect in exports from developing nations to advanced economies is attributed mainly to the quantity margin; smaller quantities of exported goods would in turn deteriorate producer surpluses in the exporting country and consumer surplus in the importing country.
- When considering exports from advanced economies to developing nations, the extensive margin is relative important; technical regulations implemented in developing economies, although thought to be less stringent, may deteriorate producer surplus in the exporting, advanced economies. While a narrow range of exported goods would imply lower producer surplus in the exporting country, a higher unit price might adversely affect consumer surplus in the importing country.

Achieving the pesticide targets announced in the F2F strategy is anticipated to lead to positive human health and environmental outcomes from a reduced environmental presence of pesticides and lower pesticide exposure for PPP users and food consumers, both in the EU and in non-EU countries. However, wider environmental, social and economic trade-offs in the export countries may occur, with developing economies being most at risk of disproportionate effects.

A reduction in productivity associated to a reduced availability of PPP and higher exposure to environmental or climatic shocks would increase food insecurity and the quality of the diets for those non-EU exporting countries affected, with unknown but important distributional effects in low-income economies, whilst also reducing the availability of exports.

Environmental impacts through land use changes and biodiversity degradation may follow if additional agricultural land is required to compensate for a reduced productivity or to address an increase in EU demand for certain crops.

10.2.5.3 *Conclusions regarding trade impacts*

The table below presents an overview of the anticipated direction of change on the main trade indicators in the baseline and in a scenario in which the pesticide targets announced in the F2F Strategy are achieved. Environmental, economic and social impacts on trade are not possible to predict at global level given the wider variety in baseline conditions, trade arrangements, etc., and both the focus group experts and the literature suggest that any effects on trade would be larger for producers exporting from developing nations than those from advanced economies. Thus, the focus of this analysis is on non-EU developing economies given the risk of disproportionate impacts from changes in trade, and the potential food security trade-offs. Specifically, the baseline column in the table presents and informed judgement on the direction of travel of the selected indicators over the 10-year period, based on the evidence base available and presented above. The second column presents an informed judgement on the additionality of SUD to those indicators, in the scenario in which the pesticide-related targets announced in the F2F Strategy are achieved. In this context, an upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator. The addition of e.g., a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD revision is expected to reinforce the baseline trends, whereas e.g., an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends. However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results.

Table 10-6. Anticipated direct and indirect impacts on selected trade indicators

Indicators	Baseline	Pesticide related targets in F2F
Effects on trade		
• EU agricultural import demand	?	?
• EU agricultural export	?	↓?
• Trade balance	?	?
Environmental, economic and social impacts resulting from changes in EU trade with developing economies		
• Farm productivity in non-EU countries	?	?
• **Food prices (non-EU consumers)**	?	↑
• Food availability (for non-EU consumers)	↓	↓↓
• Indirect land use changes in developing economies	↑	↑↑
• Biodiversity degradation	↑	↑↑
• Pesticide exposure by farmers	↑	↑?
• Pesticide exposure by consumers	↑	↑?

Note: anticipated trends depicted by arrows.
? denotes uncertainty in the projection

The evolution of trade in the baseline remains uncertain given the current policy landscape and the lack of evidence base about its impacts. The extent to which the positive and negative trends will balance out will be very much dependent on the different times at which each FTA will be ratified and will be definitively enforced. Additionally, they will be dependent on the nature and timescales of implementation of supplementary policies targeting demand side reductions, and any additional measures targeting coordination, knowledge transfer and capacity building in non-EU countries and in particular developing economies.

There is a risk for the pesticide targets announced in the F2F strategy to reinforce negative pressures on trade but the extent to which these will be responsible for limiting the projected growth in the trade balance or even lead to a reduction in trade cannot be established, particularly given the synergistic effects between the different policies. The distributional effects, whilst central to the discussion and anticipated to take place both within the EU and in exporting countries, require a granular analysis and could not be established as part of this assessment. It is important to note that even if the overall EU imports (in tons or value) may remain stable, the mix of goods and the percentage share across exporting countries may change. The consequences of any potential changes will be inversely proportional to the adaptation period and the measures established by the EU to support the transition in developing economies (e.g., access to low-cost alternatives, capacity building, knowledge sharing, support in establishing an efficient pesticide re-evaluation process in developing countries).

Given the uncertainty about trade flows and the increasing frequency of shock events resulting from climatic events and biodiversity loss, the indirect environmental, economic and social impacts in non-EU developing nations exporting to the EU are difficult to predict. In addition, they are challenging to untangle from the combined effects of the mix of policies driving the transition.

It is unlikely that achieving the pesticide targets announced in the F2F strategy will drive a meaningful reduction on pesticide exposure on their own. For a quantifiable reduction in pesticide exposure by farmers and consumers to be achieved, additional measures are expected to be required to improve pesticide re-registration, handling and use, and reduce the influx of counterfeit imports and illegal mix and sale of local variants, whilst ensuring low-cost alternatives are available.

On the other hand, if unmitigated, any direct or indirect reduction in PPP availability in developing countries could have implications on farm productivity, food availability and, ultimately, food prices and the diet in the populations of those countries and could also have consequences for EU consumers. In turn, environmental benefits associated to a reduction in pesticide concentrations could be offset by biodiversity impacts resulting from land uses changes to address yield losses and/or to meet greater demand for certain crops.

10.3 Social and health impacts

Health related indicators were selected to measure and value a set of social impacts across the food value chain. The following indicators are analysed:

- Impacts on exposure to pesticide by consumers
- Impacts on exposure to pesticides by users
- Impacts on exposure to pesticides by bystanders
- Impacts on diets and nutrition

For those indicators, we have explored the anticipated change brought through reaching the two Farm to Fork pesticide targets.

10.3.1 Exposure by consumers through pesticide residues in food and beverages

It is a regulatory requirement[545] for all EU countries to monitor food for pesticide residues, this monitoring exercise is undertaken by conducting specific surveys each year. Monitoring is conducted at the Member State level as part of a harmonised program. The major components of the national diet are usually sampled as part of this program and food surveys and the pesticides tested agreed by Member States. These surveys identify whether food that is consumed in the EU is legally compliant by ensuring that the pesticide residues found is within the Maximum Residue Level (MRL) and has been approved for use in the EU Member States. The MRL is defined by the European Commission as ''*the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly (Good Agricultural Practice)*''. While MRLS can be used as indicators of exposure MRLs/MRL exceedances do not correlate to risk to consumers from PPPs. The exceedance of MRLs are used as an indicator of consumer exposure to inform this assessment.

The information that is collected as part of these national surveys is used to inform the baseline impact on exposure by consumers through pesticide residues in food and beverages.

10.3.1.1 *Baseline levels for selected indicators*

The European Food Safety Authority (EFSA) collates data from official national surveys and testing programs undertaken by EU Member States, Iceland and Norway under Article 32 of Regulation (EC) No 396/2005. At the time of the latest survey and monitoring the UK was a Member State of the EU, thus the data included here is for the UK also. These programs include both targeted (national control programmes (NP)) and random (EU-coordinated control programme (EUCP)) sampling. Random sampling evaluates the same basket of products on a three-year rotation, so that upward or downward trends can be identified for specific goods. The EFSA reports on pesticide

[545] Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC (Text with EEA relevance)

residues from 2016[546], 2017[547], 2018[548] and 2019[549] were used to inform the baseline setting as these were some of the most recent reports available.

In the 2018 EU-coordinated control programme (EUCP, random collection), a total of 177 pesticide residues were analysed with 169 pesticides in food of plant origin and 21 in food of animal origin (13 pesticide residues were analysed for food both of plant and animal origin) in 12 food products In the 2019 EUCP sampling, 182 pesticide residues were identified: 158 in food of plant origin and 8 in food of animal origin (16 pesticide residues were to be analysed within food both of plant and animal origin).

The results from the 2017, 2018 and 2019 testing programmes can be found in the table below. The data presented in the table does not include baby foods.

Table 10-7 Results of 2017, 2018 and 2019 EUCP (random) sampling

	Residues < LOQ			Residues > LOQ / Residues ≤ MRL			Residues ≥ MRL		
	2017[a]	2018[b]	2019[c]	2017	2018	2019	2017	2018	2019
Number of samples	7,236	6,770	6,674	3,743	4,743	5,664	179	166	241
% of samples	64.9%	58%	53%	33.5%	40.6%	45%	1.6%	1.4%	2%

a: 11,158 samples analysed; b: 11,679 samples analysed; c: 12,579 samples analysed. LOQ – lowest observable quantity

The value in conducting these surveys is that it identifies MRL exceedances and presence of unapproved or prohibited pesticide residues. MRLs are not a safety standard however they can be used as an indicator of consumer exposure to PPPs. The individual MRL exceedance rates from 2018 were compared with those of 2015 because similar food commodities were sampled in both years (see Table 10-8). The number of MRL exceedances were found to increase and decrease between 2015 and 2018 depending on the food analysed. The individual MRL exceedance rate from 2019 sampling was compared to data from 2016 as similar commodities were included in both years (see Table 10-9). There were no MRL exceedances in both years with respect to cattle milk.

Table 10-8 MRL exceedances in 2015 and 2018

Food	Exceedance in 2015	Exceedance in 2018
Table grapes	1.8%	2.6% ↑
Sweet peppers/ bell peppers	1.2%	2.4% ↑
Bananas	0.5%	1.7% ↑
Aubergines	0.6%	1.6% ↑
Broccoli	3.7%	2.0% ↓
Virgin olive oil	0.9%	0.6% ↓
Chicken eggs	0.2%	0.1% ↓

546 https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2018.5348

547 https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2019.5743

548 https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2020.6057

549 https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2021.6491

Table 10-9. MRL exceedances in 2016 and 2019

Food	Exceedance in 2016	Exceedance in 2019
Strawberries	1.8%	3.3% ↑
Head cabbages	1.1%	1.9% ↑
Wine grapes	0.4%	0.9% ↑
Swine fat	0.1%	0.3% ↑
Peaches	1.9%	1.5% ↓
Lettuce	2.4%	1.8% ↓
Apples	2.7%	2.1% ↓
Tomatoes	2.6%	1.7% ↓

According to EFSA, out of a total of 91,015 samples analysed in 2018 as part of the EUCP and NP, 95.5% fell within legally permitted levels (MRLs). This was similar with the levels (95.9%) in 2017. It should be noted that a higher incidence is to be expected in NP than in EUCP, since NPs are targeting high risk products. In 2019, 96,302 samples were analysed (an increase of 5.8% compared to the previous year and 9.1% compared to 2017) and 799 pesticides were analysed. In 2019, of the 96,302 samples analysed, 96.1% fell within legally permitted levels, which was similar to the previous year. Overall, exceedance of the MRL was higher in unprocessed food (4.7%) than for processed food (3.6%). MRLs were found to exceed in 4.1% of samples in 2017, 4.5% of samples in 2018 and 3.9% of samples in 2019.

Of the 1,658 foods sampled in 2018 for infants and young children no quantifiable residues were reported in 90.3% of the samples. In 2019, of the 1,513 sampled foods for infants and young children the incidence of samples with no quantifiable residues was 97.8%, which is greater than in 2018 and 2017 of 94.6%. Samples with quantified residues (those at or above the LOQ but below or at the MRL) were found at a lower incidence in 2019 (0.9%) compared to 2018 (9.7%). MRL exceedances were reported to be 1.3% ff the 1,513 sampled foods for infants and young children (20 samples) and 0.3% were found to be noncompliant (5 samples).

The EFSA pesticide monitoring program identifies both the presence of single pesticide and multiple residues in the same sample. The presence of multiple residues in a single sample is compliant with the current legislation, but each individual residue level must not exceed its respective MRL. Activities such as washing and peeling do not completely remove the residues[550]. This means that individuals may be exposed to multiple pesticide exposures within a single food. The presence of these pesticides may arise from various processing activities through the supply chain. The MRLs set for single substances do not take into consideration the presence of mixtures in real-life conditions[551] [552]. The current measures to protect human health do not adequately address potential for mixture effects. It has been shown that combinations of chemicals present at even low levels may contribute to the overall risk of adverse health effects such as cancer and reproductive toxicity. The pesticide active substances have been shown to produce such adverse health effects at high doses under experimental conditions. In 2019, multiple residues were reported in 25,584 samples

[550] Reiler E, Jørs E, Bælum J, Huici O, Alvarez Caero MM, Cedergreen N. The influence of tomato processing on residues of organochlorine and organophosphate insecticides and their associated dietary risk. Sci Total Environ (2015) 527–528:262–9.10.1016/j.scitotenv.2015.04.081

[551] World Health Organization. Public Health Impact of Pesticides Used in Agriculture. England: World Health Organization; (1990).

[552] Kortenkamp A. Ten years of mixing cocktails: a review of combination effects of endocrine-disrupting chemicals. Environ Health Perspect (2007) 115:98–105.10.1289/ehp.9357

(27% vs. 29% in 2018). The frequency of samples with multiple residues was higher in unprocessed products compared to processed products (28% vs. 16.8%).

The policy change proposed to revise the SUD is aimed at reducing the levels of chemical pesticide use and risk, and reducing the numbers of hazardous pesticides being available. In the absence of such a policy change it is envisaged that there will be a continual, but not necessarily an upward or downward trend in the number of pesticide residues exceeding the MRL being detected in food samples.

An F2F target that is unrelated to pesticides is to achieve organic farming methods in at least 25% of the EU's agricultural land by 2030. This target will be unlikely to be impacted by policy change on pesticide use and therefore exposure to pesticides in food and beverages. Inevitably with an increase in organic farming there will be a need of non-chemical substances for crop protection. The increased use of such non-chemical substances may result in an increase in the potential for residues being present and detected in food as crop producers move to increased use of organic-approved pesticides to accommodate.

Copper exerts a strong antimicrobial effect and is approved for use in organic agriculture in the EU. Regulatory restrictions[553] are in place on the use of copper, with some Member States employing the maximum dose of 4 kg/ha/year (equivalent to a maximum application rate of 28 kg/ha of copper over a period of 7 years) and other Member States (such as Denmark and Netherlands) prohibiting the use of copper in agriculture[554]. Between 2016 and 2019, copper was one of the most frequently measured residues in samples of food intended for infants and young children by EFSA and one of the most frequently quantified pesticides overall. During this time, copper was also one the pesticides that had the highest MRL exceedances. However, the presence in food may have originated from non-pesticide uses such as food processing by-products, natural occurring substances or environmental contaminants, therefore may not necessarily be associated with pesticide uses (EFSA 2019).

According to EFSA, the levels of MRL exceedance and samples with quantified residues tend to be generally lower in organic food when compared to conventionally produced food. In 2019, there was a higher incidence of animal product samples with measurable residues in organic samples (15%) than in conventional production samples (6%). One of the main residues was that of copper. An increase in organic farming would likely affect the type and distribution of residues present on food including aggregate exposure from multiple foodstuff containing these substances (EFSA 2020). This tentatively indicates a rise in copper residues in organic produce. The use of such organic-approved pesticides in the EU will be expected to rise, unless a substitute is found (copper sulfate is a candidate for substitution) and will change the baseline over the period of 2020 to 2030. This is expected to occur in the absence of a policy change as this is separate to the SUD policies. There are no specific MRLs established for organic products and the MRLs that are set under Regulation (EC) No 396/2005 apply to organic food and to conventionally produced food. Acute and chronic exposure to excess copper has been shown to produce gastrointestinal effects and liver effects, respectively[555].

It is not possible to predict the influence that organic farming will have on the use of pesticides in the EU because the current distribution of organic farming across the EU Member States is not

[553] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1981&rid=3

[554] Jespersen, L.M., Baggesen, D.L., Fog, E. et al. Contribution of organic farming to public goods in Denmark. Org. Agr. 7, 243–266 (2017). https://doi.org/10.1007/s13165-017-0193-7

[555] National Research Council (US) Committee on Copper in Drinking Water. Copper in Drinking Water. Washington (DC): National Academies Press (US); 2000. 5, Health Effects of Excess Copper. Available from: https://www.ncbi.nlm.nih.gov/books/NBK225400/

evenly distributed[556]. Therefore, there will need to be a levelling up exercise to remove obstacles that may prevent this target being achieved. Transitioning from conventional to organic farming is labour intensive and can potentially take up to 3 years (Durham and Mizik, 2021[557]).

Third-countries may use non-EU authorised pesticides provided that the residues present do not exceed the legal limit when imported into the EU. The food commodity samples included in the EFSA survey from EU internal market comprised 63% and those coming from third countries was 27%. Approximately 7% of samples from third countries were found to exceed the MRL between 2016 and 2019 as compared to approximately 2% in EU samples. The top three pesticides originating from a third-country that were reported to exceed the MRL between 2016 and 2019 were those that were not approved as a pesticide or a biocide under the respective EU Regulations. Examples of these include anthraquinone (CAS RN 84-65-1), nicotine (CAS RN 54-11-5) and tolfenpyrad (CAS RN 129558-76-5).

Nicotine belongs to class Ib of the WHO Classification of Pesticides by Hazard. This classification process uses the Acute Toxicity Hazard Categories from the GHS as the starting point for classification. Classification Ib is defined as those that are highly hazardous with low LD50 values. Anthraquinone is classified as U referring to a pesticide that is unlikely to present acute hazard in normal use. Tolfenpyrad has not been evaluated by the WHO for classification purposes, but the substance is reported to have an oral LD50 of 386 mg/kg body weight and a dermal LD50 of 2000 mg/kg body weight[558], which could be classified as class II (moderately hazardous) according to the WHO guideline to classification[559]. The majority of non-EU approved pesticides exceeding the MRLs in food samples that originated from the EU reporting countries between 2016 and 2019 were chlordecone (CAS RN 143-50-0) and nicotine. The use and production of chlordecone is prohibited or severely restricted by the Stockholm Convention on persistent organic pollutants[560]. Moreover, chlordecone is considered to be obsolete as a pesticide and not classified under WHO Classification of Pesticides by Hazard scheme. It is evident that non-EU approved pesticides are being imported into the EU despite border controls being in place and this baseline is unlikely to change in the absence of policy change.

There was a slight increase in the number of samples of unknown origin (11.3% in 2019 vs. 10.1% in 2018). This raises concerns regarding the way in which this information is reported. In 2019, EFSA reports that at least 1.6% of the samples of unknown origin exceeded the MRL. The majority of non-EU approved pesticides exceeding the MRLs in food samples of unknown origin between 2016 and 2019 were chlordecone and nicotine. The data indicates that the samples of unknown origin may in fact originated from the EU, but this is speculative.

The EFSA surveys highlight the issue and concern relating to the presence of non-EU approved active substances reported to exceeding the EU legal limit. In theory, active substances not approved in the EU should not be present in samples grown in the EU. However, non-EU authorised pesticides have been detected in food commodities grown in EU reporting countries that were non-compliant as identified in the 2019 EFSA report include the following: acephate, carbofuran, chlorfenapyr, chlorothalonil, chlorpropham, clothianidin, cyfluthrin, dieldrin, iprodione, methomyl, oxadixyl and triadimefon. While in 2018, the non-EU authorised pesticides detected in food commodities grown in EU reporting countries that were non-compliant reported were omethoate,

[556] https://www.efsa.europa.eu/en/funding-calls/reaching-farm-fork-target-ri-scenarios-boosting-organic-farming-and-organic

[557] Durham, Timothy C., and Tamás Mizik. 2021. Comparative Economics of Conventional, Organic, and Alternative Agricultural Production Systems. Economies 9: 64. https://doi.org/10.3390/economies9020064

[558] http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/1687.htm#3

[559] https://www.who.int/publications/i/item/9789240005662

[560] http://www.pops.int/

bitertanol, carbendazim, flusilazole, dieldrin, chlorfenapyr, triadimefon, acephate, fenitrothion and iprodione. Some of these substances may be present as a result of historical use where they are persistent in the environment and therefore remain in the foods that are consumed. The illegal trade of pesticides that may include non-EU approved active substances may also contribute to the presence. In fact, 1203 tonnes of illegal pesticides were seized between 13 January and 25 April 2021 in a Europol coordinated operation (Silver Axe) that targeted the trade in counterfeit and illegal pesticides[561].

To summarise, it is evident that despite the regulatory measures currently in place in the EU the potential for MRL exceedances to occur remains. It is worth noting here that these MRL exceedances are a snapshot in time of the situation of pesticide residues in those products that are the most widely consumed in the EU. The MRLs are an estimation of the expected residue distribution calculated using statistical methods. Therefore, in the absence of policy change it is anticipated that approximately 1% of MRL exceedances is to be expected even if good agricultural practices are fully respected. Consumer exposure to pesticides through consumption of food is unlikely to change significantly in the absence of policy change. Non-EU approved pesticides are likely to continue being identified in food samples despite the current regulatory controls in place.

Health risks associated with exceedances of the health-based guidance value

Following an exceedance of the MRL or when there is a pesticide for which an MRL has not been set specific health-based guidance values are calculated. These health-based guidance values are based on current scientific knowledge (safety data) and may be different to the MRL. Health-based guidance values is set for the maximum exposure to a substance that is not expected to result in appreciable risk to health. This would take into account any uncertainties in the data used and likely duration of consumption.

Dietary exposure to a pesticide active substance that exceeds its health-based guidance value may lead to a negative effect on the health of the exposed individual. There are studies reporting an association between exposure to pesticide and adverse health effects[562]. For example, diabetes has been linked to exposure to organochlorine pesticides in Mexico, Africa and Europe[563] [564] [565]. Susceptible groups such as pregnant women and children are considered the most vulnerable population groups to neurotoxic and endocrine disrupting properties of the most prevalent pesticides[566].

EFSA uses information collected from the national surveys on dietary exposure and occurrence data of pesticides to assess the short-term and long-term health risks posed by any exceedance of the MRLs or a specific health-based guidance value. Exceeding the MRLs may not necessarily mean that

[561] https://www.europol.europa.eu/newsroom/news/pesticides-worth-to-%E2%82%AC-80-million-in-criminal-profits-seized-during-operation-silver-axe-vi

[562] Rani, L., Thapa, K., Kanojia, N., Sharma, N., Singh, S., Singh Grewal, A., Lal Srivastav, A., Kaushal, J. (2021). An extensive review on the consequences of chemical pesticides on human health and environment. Journal of Cleaner Production. 283: 124657. https://doi.org/10.1016/j.jclepro.2020.124657

[563] Cox, S., Niskar, A., Narayan, V., Marcus, M., 2007. Prevalence of self-reported diabetes and exposure to organochlorine pesticides among Mexican Americans:hispanic health and nutrition examination survey, 19821984. Environ. Health Perspect. 115 (12), 1747e1752. https://doi.org/10.1289/ehp.10258.

[564] Azandjeme, C.S., Bouchard, M., Fayomi, B., Djrolo, F., Houinato, D., Delisle, H., 2013. Growing burden of diabetes in sub-saharan Africa: contribution of pesticides? Curr. Diabetes Rev. 9 (6), 437e449. https://doi.org/10.2174/15733998113099990078

[565] Evangelou, E., Ntritsos, G., Chondrogiorgi, M., Kavvoura, F.K., Hernandez, A.F., Ntzani, E.E., Tzoulaki, I., 2016. Exposure to pesticides and diabetes: a systematic review and meta-analysis. Environ. Int. 91, 60e68. https://doi.org/10.1016/j.envint.2016.02.013.

[566] https://www.hbm4eu.eu/the-substances/pesticides/

there is an immediate risk to health. However, exceeding the health-based guidance value may begin to erode the margin of safety. Typically, short term exceedances of the health-based guidance values do not result in adverse health effects. Long-term exceedances may give rise to increased risk of adverse health effects. Under the European Rapid Alert System samples may be withdrawn from the market when there is a non-compliant result and/or an exceedance of the health-based guidance value. Moreover, legal action may be undertaken to restrict the movement of such foods in the EU market.

Occurrence of adverse health effects as a result of exceeding the MRL or health-based guidance value is not easily measurable due to the vast number of confounding factors and lack of a suitable or harmonised monitoring system in place across the reporting countries.

Acute risk assessment

Acute exposure refers to exposure to a food within a short time frame (e.g., on a single day or meal). Dietary exposure per pesticide residue was compared to the active substance's acute health-based guidance value known as acute reference dose (ARfD), where the ARfD refers to an estimate of the amount of a substance in food or drink, expressed on a body weight basis that can be ingested in a period of 24 hours or less without appreciable health risk. In 2018, 182 pesticides in 22,752 food samples underwent acute risk assessment by EFSA. Of these, 33 pesticides exceeded the acute health-based guidance values in 327 samples. In 2019, 19,767 samples were assessed for acute exposure for the 182 pesticide residues covered in the EUCP and 28 pesticides residue levels exceeded the acute health-based guidance value in 170 samples (0.9%). EFSA concluded that the number of exceedances of the health-based guidance value (ARfD) in both 2018 and 2019 for acute dietary exposure would be unlikely to pose a health concern for consumers. This means that while there was an acute health hazard for the 28 pesticide residues that exceeded the ARfD there was no accompanying risk because exposure was low.

Chronic health risk assessment

Chronic exposure refers to the average daily consumption of pesticides over a prolonged period of time. For the assessment of chronic health risk, the estimated dietary exposure per pesticide residue was compared with the active substance's chronic health-based guidance value or the acceptable daily intake (ADI) where the ADI refers to an estimate of the amount of a substance in food or drink, expressed on a bodyweight basis (e.g., mg/kg bodyweight), that can be ingested daily over a lifetime by humans without appreciable health risk. Chronic exposure was estimated for 182 pesticides in a total of 80,733 samples (2018) and 79,895 samples (2019) and exposure for all pesticides was below the ADI except for one pesticide (dithiocarbamates) in 2018. EFSA concluded that exposure to the pesticide residues was below the health-based guidance values (ADI) where available for chronic dietary exposure would be unlikely to pose a health concern for consumers.

EFSA concludes that exceedances of the health-based guidance values for acute and chronic exposures between 2016 and 2019 do not pose a risk to human health. ARfDs and ADIs have margins built into the setting of values to allow for short term exceedances. It would be difficult to measure the impact on disease/pathology in exposed individuals given that small perturbations in the MRLs and/or health-based guidance values may not contribute significantly or measurably to adverse health effects at a population level. While this is a data gap it is unclear how this data gap may be addressed.

10.3.1.2 *Impacts of achieving the pesticide related targets announced in the F2F strategy on the selected indicator*

Since no information on health risks was available in relation to the exceedance of MRLs, the impacts will mainly focus on the ability of the policy action to reduce the occurrence of MRL exceedance.

Impact of meeting pesticide related targets

The pesticide related targets of the F2F strategy includes reduction in the use and risk of chemical pesticides by 2030 and reduction of the use of the more hazardous pesticides also by 2030. The realisation of these targets will be expected to reduce the levels and incidence of exposure to pesticides in food and beverages. Therefore, a reduction in the use and risk and move to the use of less hazardous chemical pesticides should reduce overall exposure. This would inevitably decrease the potential for adverse health effects caused by the presence of pesticides in food.

However, there are aspects or concerns that the reduction targets for the use of pesticides will not address. It is clear from the EFSA reports on pesticide residues that food samples contain more than one pesticide. The extent to which each Member State will ensure that their national action plan address future regulatory developments will differ, and this will introduce uncertainty and variability in consumer exposure to multiple pesticides through food and beverages. There is a risk of mixture effects following exposure to multiple pesticides and currently the risk assessment process in the EU does not address this aspect. The introduction of pesticide related targets to be realised by 2030 will be unlikely to lower the risk of adverse health effects caused by mixtures of pesticides. Some Member State countries have put measures in place that will ensure that risk assessment methods will reflect evolving scientific and technological developments. For this to be meaningful the approach must be harmonised across the EU countries.

While it is clear that meeting pesticide related targets to reduce the use of pesticides and to increase the use of less hazardous would ultimately reduce human exposure to these substances, it is unclear whether the positive impact on human health can be measured within the 10-year timeframe at a population level. The presence of confounding factors may further impede efforts to measure the impact of pesticide residues on food.

Imports from Third Countries

Imports of food from third-countries may increase as a result of policy change due to increase in price of food produced in the Member States. This would likely increase the potential for food products containing pesticides that are not approved for use or prohibited in the EU as well as food containing pesticides that exceed the MRL. While the policies under the SUD may go some way in reducing the exposure of consumers to regulated pesticides through the diet, it may not necessarily eradicate or reduce exposure to non-approved or prohibited pesticides from third countries. This would require increased monitoring to increase the efficiency of the European control systems to continue to ensure a high level of consumer protection. Moreover, a stronger connection to payments made under the CAP could reduce negative effects on EU producers.

Direct impacts on food production systems in third countries are not expected from the revision of this Directive, as the use phase only within the limits of the EU is targeted. Spill-over effects of pesticide risk reduction policies could be envisioned just like an increase in production to supply EU markets.

10.3.1.3 *Conclusions regarding exposure through pesticide residues*

Reaching the F2F targets on pesticides have the potential to lower exposure to pesticide residues (short term and long term). However, it is not possible to quantify the health impact of reduced exposure in a meaningful manner, based on current knowledge and data availability.

The table below presents an overview of the anticipated direction of change on selected indicators resulting from achieving the pesticide targets announced in the F2F strategy, relative to the baseline.

The table below presents a summary of development of indicators. An upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator. The addition of e.g., a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD revision is expected to reinforce the baseline trends, whereas e.g., an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends. However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, particular uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results.

Table 10-10. Summary of development of indicators

Indicators	Baseline	Pesticide related targets in F2F	Justification
Effects on Health			
• **Reduction in MRL exceedance**	–	↓	The anticipated reduction in the MRL exceedances is driven by the reduction in the use chemical pesticides and reduction of the use of the more hazardous pesticides by 2030 therefore the likelihood of the presence of pesticides in the food that is consumed is expected to decline.
• **Pesticide exposure by consumers**	–?	↓	The anticipated decrease in pesticide exposure by consumers is linked to to the reduction in the use chemical pesticides by 2030 therefore the likelihood of the presence of pesticides in the food that is consumed is expected to decline.
• **Exposure to mixtures**		↓?	The reduction of pesticide use by 2030 will be unlikely to lower the risk of adverse health effects caused by mixtures of pesticides given that mixture effects are currently not addressed in the EU.

Note: anticipated trends depicted by arrows.
? denotes uncertainty in the projection

10.3.2 *Exposure by pesticide users from pesticide handling and application*

Exposure to pesticides occurs during handling and application activities. Users of pesticides include both occupational and general use. Occupational exposure typically occurs in workers involved in the manufacture of pesticides and among specific users in public health (e.g., exterminators of house pests). Occupational exposure to pesticides is not within the scope of this assessment. Occupational exposure also includes agricultural workers, such as farmers and professional applicators of pesticides[567] [568]. In the EU, farmers and farm workers are likely to face a relatively greater risk of exposure to pesticides than typical non-agricultural workers. Exposure to pesticides tend not to be uniform or consistent across farms across the EU Member State countries and in theory pesticide exposure should be focussed on individuals who are certified pesticide applicators.

[567] Woodruff T.J., Kyle A.D., Bois F.Y. Evaluating health risks from occupational exposure to pesticides and the regulatory response. Environ. Health Perspect. 1994;102:1088–1096. doi: 10.1289/ehp.941021088.

[568] Maroni M., Fait A., Colosio C. Risk assessment and management of occupational exposure to pesticides. Toxicol. Lett. 1999;107:145–153. doi: 10.1016/S0378-4274(99)00041-7.

10.3.2.1 *Baseline levels for selected indicators*

There can be a number of ways individuals can become exposed to pesticides during use. For instance, those who mix, load, and spray pesticides can be exposed due to spills and splashes, direct spray contact as a result of faulty or missing protective equipment, or spray drift. However, exposure can also occur from activities that are not directly related to pesticide use, these may include for example working in the vicinity that has been treated with pesticides. Therefore, it is conceivable that those who work with pesticides are likely to have the greatest exposure. In addition to exposure by normal usage, exposure may also occur as a result of accidental spills of chemicals, leakages, or faulty spraying equipment. Another factor which is likely to affect exposure of pesticide users is their general hygiene practices. Ensuring that appropriate work attire that is protective can reduce pesticide exposure.

Spraying crops with pesticides would inevitably lead to exposure to the handler and this can be by direct exposure through the skin and by inhalation to clouds/droplets of pesticides. This may cause acute toxicity and/or may lead to chronic health effects. Member States have put in place training to ensure that professional PPPs are only used by appropriately trained and certificated operators. This ensures that all professional users of PPPs are trained to a minimum agreed standard and in possession of an accredited certificate to prove this. The training requirements for professional users is designed to ensure that certified individuals have complied with the prescribed standard are sufficiently skilled to ensure that the application of pesticide products is done in a manner that minimises human health risks and impacts.

Article 67 of Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market[569] states that "Producers, suppliers, distributors, importers, and exporters of plant protection products shall keep records of the plant protection products they produce, import, export, store or place on the market for at least 5 years. Professional users of plant protection products shall, for at least 3 years, keep records of the plant protection products they use, containing the name of the plant protection product, the time and the dose of application, the area and the crop where the plant protection product was used". Member States collect and report on suspected cases of poisoning from pesticides. However, this information is confidential and not available therefore a baseline indicator review is not possible. Regulation (EC) No 1185/2009 concerning statistics on pesticides[570] obliges Member States to "collect the data necessary for the specification of the characteristics listed in Annex I on an annual basis and for the specification of the characteristics listed in Annex II in five-year periods" including "information concerning the placing on the market and use of pesticides taking into account, in particular, the obligations pursuant to Article 67 of Regulation (EC) No 1107/2009". Aerial spraying of pesticides requires specific derogations by the Member State according to the SUD. This will add to the database of use data of pesticides in the EU.

While there is a lack of data available for exposure of pesticide handlers during normal use there is a vast amount of information available for pesticide poisonings through accidental or intentional consumption in the literature. It is beyond the scope of the current review to comment on the information available.

Pesticide poisoning does not always result in fatalities, indeed there can be non-fatal acute pesticide poisonings. It is pertinent to note that fatalities alone may not provide a good basis for assessing pesticide exposure. For example, in a systematic literature review it was reported that between 2006 and 2018, there was an estimated 386 million non-fatal acute pesticide poisoning reported

[569] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R1107&from=EN

[570] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R1185&from=EN

for the global farming/occupational population[571]. In this review, data for pesticide-related fatalities in Europe was based on 35 reporting countries, while there were only 4 countries for which data on non-fatal acute pesticide poisonings could be located by the study authors in the literature. It is pertinent to note here that this is a single publication and may not be representative of actual data.

Member States collect data on pesticide poisoning, but the data that is available to the public does not distinguish between bystander exposure versus professional user exposure. Pesticide poisoning resulting from intentional consumption is beyond the scope of this current assessment. Moreover, the poisoning data also does not distinguish between biocidal and pesticide exposure related poisoning given that these are covered under two separate legislations in the EU.

In the absence of a policy change in the SUD it is likely that exposure to pesticides will continue to grow, however in 2019 a trend was found as growth in the sales of pesticides containing non-chemical active substances increased and the quantity of the more hazardous pesticides placed on the market was decreased[572]. Therefore, while exposure to chemical pesticides may decrease in the absence of a policy change, there may be an increase in exposure to less-hazardous pesticides. This would reduce the risk of health effects of pesticide handlers in the baseline.

The F2F target of 30% of all food production to be organic by 2030 may change the type of pesticides that handlers are exposed to as they move to those pesticides that are permitted under organic farming rules.

Directive 2009/127/EC - regarding machinery for pesticide application - harmonises manufacturing standards for new equipment for applying pesticides before the equipment may be placed on the market by the manufacturer. For those machinery already in use this Directive introduces requirements for the inspection and maintenance to be carried out on such equipment. These activities are expected to play a significant role in reducing the adverse effects of pesticides on human health. Directive 2009/128/EC includes prevention of spreading of harmful organisms by hygiene measures, such as by regular cleansing of machinery and equipment and regular inspection of equipment that is already in use. These activities can also be used to inform the baseline.

There is a high level of uncertainty around the quality and reliability of data currently available for exposure of workers to pesticides. This is further exacerbated by the lack of data on contact of pesticide handlers with treated crops, where exposure may be different depending on the extent of time after pesticide application.

In summary, the baseline exposure to pesticides and the potential for health effects associated with this exposure is greatly influenced by confounding factors and the lack of reliable data on usage. There is likely to be a decrease in pesticide exposure by professional users during baseline as pesticides are withdrawn from use or different pesticides are used as part of the organic farming initiative or IPM measures.

10.3.2.2 *Impacts of achieving the pesticide related targets announced in the F2F strategy on the selected indicator*

The following section discusses the impacts of achieving the pesticide related targets in the F2F strategy on the ability of the policy action to affect exposure of professional users to pesticides and health risks in relation to acute or chronic poisoning incidents.

The pesticide related targets of the F2F strategy includes reduction in the use and risk of chemical pesticides by 2030 and reduction of the use of the more hazardous pesticides also by 2030. The

[571] Boedeker, W., Watts, M., Clausing, P. et al. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. BMC Public Health 20, 1875 (2020).

[572] https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/harmonised-risk-indicators/trends-eu_en

realisation of these targets will be expected to reduce exposure to pesticides by professional users. Therefore, a reduction in the use and move to the use of less hazardous chemical pesticides should reduce overall exposure. This would inevitably decrease the potential for acute poisoning incidents which may lead to chronic health effects. A valuable indicator of poisoning following normal pesticide use (i.e., from the use of EU-approved pesticides used in accordance with instructions for use and employing machinery that is up to the current standards) would be acute non-fatal pesticide poisoning and subsequent development of chronic health effects. This would allow for a more meaningful evaluation of the impact on the occurrence of health effects associated with use of pesticides following a reduction of pesticide use and decrease in the use of hazardous pesticides. This data is currently lacking and is considered a data gap.

Implementation of the SUD policies include training relevant individuals involved at all levels of the industry, including professional users/sprayer operators and to test all pesticide application equipment. The targeted training of such individuals will help to reduce the levels of pesticides these individuals would become exposed to. The training would include aspects such as good hygiene practices, appropriate protective clothing and advice on how to care for machinery that is involved in pesticide applications. These actions will reduce the risk of accidental and non-intentional exposure to pesticides. IPM introduces the requirement for pest management including avoiding sole reliance on pesticides. Professional users of pesticides will be expected to follow a strategic and more targeted use of pesticides which would mean that exposure will be impacted positively.

10.3.2.3 *Conclusions on exposure by pesticide users*

Reaching the F2F targets on pesticides have the potential to lower exposure to pesticide handlers (short term and long term). This would likely have an impact on the health of these users given that there will be a reduction in the use of hazardous pesticides. However, it is not possible to quantify the health impact of reduced exposure in a meaningful manner, given that while there is data on acute poisoning events in pesticide handlers there is no such data from the normal use of pesticides in professional users.

The table below presents an overview of the anticipated direction of change on selected indicators resulting from achieving the pesticides targets announced in the F2F strategy, relative to the baseline.

The table below presents a summary of development of indicators. An upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator. The addition of e.g., a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD revision is expected to reinforce the baseline trends, whereas e.g., an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends. However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, particular uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results.

Table 10-11. Summary of development of indicators

Indicators	Baseline	Pesticide related targets in F2F	Justification
Effects on Health			
• **Pesticide exposure by**	↓	↓	A reduction in the use of pesticides and move to the use of less

professional users			hazardous chemical pesticides should reduce overall exposure by professional users.
• **Incidence of adverse health effects (acute and chronic) from exposure**	↓	↓	A reduction in the use of pesticides and move to the use of less hazardous chemical pesticides should reduce overall exposure by professional users, which in turn would lower the likelihood of the incidence of adverse health effects that are attributed to pesticide exposure.
• **Exposure to organic-approved pesticides**	↑	↑	Exposure to organic-approved will increase regardless of the pesticide related targets in F2F. This is due to requirement of 30% of all food production in the EU to be organic by 2030, which may change the type of pesticides that handlers are exposed to as they move to those pesticides that are permitted under organic farming rules.

Note: anticipated trends depicted by arrows.
? denotes uncertainty in the projection

10.3.3 Exposure by bystanders from pesticide application

Bystanders are people who are not involved in working with pesticides but may be located within or directly adjacent to the area where product application is in process or has recently been completed. Bystanders are assumed to be exposed during a short period of time and take no action to avoid or control exposure. Commission Regulation (EU) No 284/2013[573] setting out the data requirements for plant protection products concerning the placing of plant protection products on the market addresses the assessment of bystander exposure to pesticide products. As part of this regulation, it is a requirement to provide an estimation of acute and chronic exposure to bystanders. Bystander exposure that is likely to arise under the expected conditions of use should be evaluated under this regulation which may provide information on cumulative and synergistic effects resulting from more than one pesticide active substance. Exposure can include during or after the application of pesticides by the dermal and inhalation routes of exposure. Oral exposure may occur in infants and toddlers through accidental hand-mouth transfer.

10.3.3.1 *Baseline levels for selected indicators*

Pesticides are applied using hydraulic and hydro-pneumatic sprayers and therefore bystander exposure is primarily associated with spray application in properties that are adjacent to the bystander or where they had access to treated land. Exposure of bystanders to pesticides has been linked to adverse health outcomes such as reproductive effects or cancer[574]. For example, diabetes

[573] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0284&from=EN

[574] Shirangi, A.; Nieuwenhuijsen, M.; Vienneau, D., 2009. Bystander Agricultural Pesticides Exposure and the Risk of Adverse Reproductive Outcomes: A Review of the Literature, Epidemiology: November 2009 - Volume 20 - Issue 6 - p S184 doi: 10.1097/01.ede.0000362622.69114.30

has been linked to exposure to organochlorine pesticides[575] [576] [577]. However, a causal link between exposure and adverse health effects is confounded by a lack of data on exact exposure information. Bystander exposure is often evaluated after the event using self-reported questionnaires, which may lead to subjective reporting by the affected individuals. Complainants may have used pesticide products in the home and therefore the exact source of exposure may not always be known or there may be instances of multiple sources of exposure to pesticides. Some form of pesticide use in the domestic environment was found in 45% of individuals attending GP surgeries in the UK in the week before consultation[578]. This would affect the levels of background exposure to pesticides which may contribute to the cumulative effects of mixtures of low levels of pesticides.

A systematic review evaluated the epidemiological evidence for the period of 1950 to 2007 between bystander pesticide exposure and adverse birth outcomes[9]. The authors concluded that there was a weak link between bystander pesticide exposure and adverse birth outcomes. However, this finding was limited by weaknesses in the exposure assessment and the possibility of chance or confounding bias. Bystanders are likely to be heterogenous in their genetic and phenotypic characteristics, which means that the way in which each bystander responds to or is affected by pesticide exposure may be different.

A modelling framework for quantifying exposure of bystanders to pesticide spray drift from agricultural fields show that exposure of bystanders is limited relative to total population exposure from ingestion of pesticide residues in crops[579]. However, bystander exposure to spray drift may be relatively higher than those individuals not living in close proximity to agricultural land where the pesticides are being employed.

The EFSA hosts a database that contains the results of a systematic literature review on the non-dietary exposure assessment to pesticides for bystanders and residents, as well as daily air concentration of pesticides, drift values from spray, seed and granular applications, and dislodgeable foliar residues[580]. Some Member States, such as Belgium[581], collect data on incidents in which bystanders have complained about ill health as a result of alleged pesticide exposure so that new issues and trends can be identified; and to inform the pesticides approval process. As an example, the proportion of the total number of incidents reported to the UK HSE in 2002/2003 was 13% who were classified as confirmed or likely for an association between pesticide usage and the alleged ill health. Ten years later (2012/2013) the proportion of the total number of incidents was 20% who were classified as confirmed or likely for an association between pesticide usage and the alleged ill health[582]. The data, however, did not provide information on the level of exposure (quantification) that was attributed to the ill health.

[575] Cox, S., Niskar, A., Narayan, V., Marcus, M., 2007. Prevalence of self-reported diabetes and exposure to organochlorine pesticides among Mexican Americans:hispanic health and nutrition examination survey, 19821984. Environ. Health Perspect. 115 (12), 1747e1752. https://doi.org/10.1289/ehp.10258.

[576] Azandjeme, C.S., Bouchard, M., Fayomi, B., Djrolo, F., Houinato, D., Delisle, H., 2013. Growing burden of diabetes in sub-saharan Africa: contribution of pesticides? Curr. Diabetes Rev. 9 (6), 437e449. https://doi.org/10.2174/15733998113099990078

[577] Evangelou, E., Ntritsos, G., Chondrogiorgi, M., Kavvoura, F.K., Hernandez, A.F., Ntzani, E.E., Tzoulaki, I., 2016. Exposure to pesticides and diabetes: a systematic review and meta-analysis. Environ. Int. 91, 60e68. https://doi.org/10.1016/j.envint.2016.02.013.

[578] https://cot.food.gov.uk/sites/default/files/cot/cotstatementrcep0605pdf.pdf

[579] Ryberg MW, Rosenbaum RK, Mosqueron L, Fantke P. Addressing bystander exposure to agricultural pesticides in life cycle impact assessment. Chemosphere. 2018 Apr;197:541-549. doi: 10.1016/j.chemosphere.2018.01.088. PMID: 29407816.

[580] https://www.efsa.europa.eu/en/microstrategy/pesticides-usage

[581] https://ec.europa.eu/food/system/files/2019-03/pesticides_sup_nap_bel_en.pdf

[582] https://www.hse.gov.uk/agriculture/pdf/pir1213.pdf

Thirty countries, the European Environment Agency and the European Commission were part of an initiative in coordinating and advancing human biomonitoring in Europe called HBM4EU[583]. As part of this initiative, gaps in knowledge were identified for potential adverse health effects in humans at population-level exposures to pesticides and where human biomonitoring data was required to evaluate safe exposure levels. The HBM4EU project evaluated urinary levels of certain pesticides and their metabolites and while this information provides details on exposure to the respective pesticides it does not however, distinguish between exposure from residues in food versus non-dietary exposure.

With the continued implementation of SUD and F2F related actions such as increase in organic farming and IPM means that there should be a reduction in baseline bystander exposure. For instance, IPM introduces strategic and targeted use of pesticides using optimised spraying technology that would reduce the loss of pesticides to spray drift. It is estimated that spray drift accounts for up to 50% loss of pesticide during use.

In summary, given the lack of information to form a causal association between bystander exposure and linked adverse health effects it is difficult to form a meaningful baseline. Added to this the heterogeneous representation of the bystander population that exhibit inter-individual variation means that it complicates efforts to form a baseline of bystander exposure.

10.3.3.2 *Impacts of achieving the pesticide related targets announced in the F2F strategy on the selected indicator*

It is difficult to predict the impact that the pesticide related targets in the F2F strategy will have on bystander exposure. This is mainly due to the difficulty in knowing the exact exposure level to the pesticide as this is often not measured, the heterogeneity of the exposed population (including vulnerable subpopulations) and exposure via other routes. It may be helpful that in addition to the changes in pesticide use and use of less hazardous substances there should be a concerted effort in understanding bystander exposure levels. One possible method for determining this could be by biomonitoring for exposure. However, given the various ways in which pesticides are known to act means that this would involve being able to detect the parent pesticide, its metabolite or reaction product in biological media. This can be invasive in case of determining exposure in blood or urine and measurement depends on the metabolic capacity of the individual, half-life of the pesticide and its metabolites as well as availability of biological reference values. The HBM4EU data reported urinary levels of certain pesticides and their metabolites, but it was not possible to distinguish between exposure from residues in food versus non-dietary exposure[584].

10.3.4 *Impact on diets and nutrition*

10.3.4.1 *Baseline levels for selected indicators*

Farm productivity and profitability are subject to external drivers, and these have the potential to impact yields and types of crops, cost of inputs, and ultimately changes in revenue of the farms. Based on the 2020-2030 EU Agricultural Market Outlook, the total value of crop production is expected to increase in 2020-2030 period in nominal terms by 21%. During this period, costs such as feed costs (for animal production), seed costs, energy and fertiliser costs, and other input costs are also expected to increase. The market outlook report predicts that the nominal agricultural income is expected to increase in the outlook period at 11% in 2020-2030, which may have implications on cost of food. According to the JRC economic outlook, declines in available arable

[583] https://www.hbm4eu.eu/about-hbm4eu/

[584] https://www.hbm4eu.eu/the-substances/pesticides/

cropland (due to increasing forest and pastureland) together with improving yields due to digitisation and improved farming practices means that EU production is expected to remain largely stable. EU producer and consumer prices are both expected to reduce, due to a combined effect of GDP, oil price and consumption shocks.

The influence of food cost on the quality of diet can exacerbate social inequalities[585]. Life expectancy can be increased with a balanced and varied diet. In 2019, the proportion of adults aged 18 and over who were overweight or obese in the EU, was approximately 52.7%[586]. Substantial differences exist in the EU regarding the proportion of adults who are overweight or obese in terms of gender and socio-economic background. Being overweight and obese is one of seven largest risk factors for premature death in the EU.

Poor nutrition caused by unhealthy diet is contributing to the burden of non-communicable diseases, such as cardiovascular diseases, type 2 diabetes and some types of cancers. Poor nutrition is being blamed on excessive consumption of energy, saturated fat, trans fats, sugars and salt, as well as low consumption of vegetables, fruits and whole grains in EU Member States[587]. Such a diet contributes to rising obesity, shorter life expectancy and harms quality of life. There is a need to improve the availability, affordability and attractiveness of healthy foods and this is proposed to being achieved by Member States implementing government-approved policies that aim to promote healthy diets. The European Food and Nutrition Action Plan 2015–2020 intends to reduce the burden of preventable diet-related non-communicable diseases, obesity and all other forms of malnutrition in Europe. The action plan aims to improve the health and quality of life of the European population by increasing accessibility of a healthy and varied diet (that is both available and affordable).

To summarise, the production and yield of crops in Europe is expected to increase during baseline to support the increasing needs by consumers. Government-led initiatives to increase affordability and availability of healthy food options, would be expected to offset the predicted rise in costs such as feed (for animal production), seed, energy and fertiliser. However, an increase in organic farming and the continued implementation of IPM, if not mitigated, may result in increased cost of food as food producers attempt to recoup costs associated with the new systems and this may influence the availability of crops potentially pushing cost of food higher. A recent report[588] published by the European Commission states that prices of arable crop commodities are rising possibly as a result of compensation for their growing input costs. An increase in cost of food will affect the type of diet individuals choose which may negatively affect nutrition and thereby health. Affordability and availability of healthy food is pertinent to ensure that the consumer can choose a healthy diet thereby preventing nutritional deficiencies that may lead to poor health outcomes such as obesity, cardiovascular disease and mortality.

10.3.4.2 *Impacts from achieving the pesticide-related targets announced in the F2F strategy*

Achieving the pesticide-related targets announced in the F2F strategy may lead to changes in agricultural area, which may then have a negative impact on yield and production. A number of studies predicted the impact on food production if the F2F targets are met. In each of these studies the analysis of the adoption of the two proposed pesticide related F2F targets could lead to a reduction in EU agricultural food production across all commodities. With a reduction in pesticide

[585] James WP Nelson M Ralph Aet al. . Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. BMJ. 1997;314:1545–1549.

[586] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Overweight_and_obesity_-_BMI_statistics

[587] https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/nutrition

[588] https://op.europa.eu/en/publication-detail/-/publication/57d860fd-9cc9-11eb-b85c-01aa75ed71a1/language-en/format-PDF/source-207940309

use, food production would be expected to decrease whilst the market adjusts to new techniques and approaches and resultantly food prices would rise.

Increases in food prices force people to adjust as consumer purchasing power decreases and this is likely to have a negative impact on household dietary choices and nutrition. Food price in the EU is also being impacted by an increase in global prices of foodstuff such as cereals[589].

In a study undertaken to explore the impact of food price policies on the nutritional quality of food baskets chosen by low- and medium-income households showed that low-income individuals selected less expensive and less healthy baskets than medium-income ones[590]. In a systematic literature review of publications linking food prices, dietary quality, and socioeconomic status revealed that foods of lower nutritional value and lower-quality diets were likely to be selected by groups of lower socioeconomic status because they cost less per calorie[591]. This may then lead to widening socioeconomic disparities given the higher cost of consuming a healthy diet.

A reduction in dietary quality, such as a shift towards more calorically empty foods, may compromise child growth and cognitive development, increasing risk of nutrient deficiencies (FAO 2012[592]). Nutritional deficiencies, such as vitamin A deficiency and iron deficiency anaemia are caused by diets low in animal source foods, fat, and certain fruits and vegetables. These types of deficiencies are associated with impaired immunological function, increased risk of maternal and infant death, and impaired eyesight.

A loss in dietary quality may lead to health shocks as the immune system weakens and susceptibility to disease increases. Vulnerable members of the population such as children, women and poor families are likely to be impacted the most by poor quality of diet. Poor nutrition in children has also been linked to decreased school attendance, which can play an important part in delivering information about good nutrition as well as for direct nutrition interventions.

10.3.4.3 *Conclusions on diets and nutrition*

The baseline between 2020-2030 is expected to see lower food prices by increasing yield from the use of digitisation and improved farming techniques. A reduction in the use and risk of pesticides, and reduction in the use of more hazardous pesticides may lead to reduced crop yield. This has the potential to drive cost of food up which may impact on the choices individuals make about the types of food that they consume. However, given that there is expected to be a small reduction in the baseline cost of food and the implementation of government lead initiatives there may be a scenario where price of food does not increase during baseline to the extent that diet and thereby nutrition is negatively affected.

The table below presents an overview of the anticipated direction of change on selected indicators resulting from achieving the pesticide targets announced in the F2F strategy, relative to the baseline.

The table below presents a summary of development of indicators. An upward or downward arrow [↑ or ↓] in the baseline represents a projected increase or decrease in a particular indicator. The addition of e.g., a second consistent upward or downward arrow [↑↑ or ↓↓] depicts that the SUD

[589] https://op.europa.eu/en/publication-detail/-/publication/57d860fd-9cc9-11eb-b85c-01aa75ed71a1/language-en/format-PDF/source-207940309

[590] Darmon, N., Lacroix, A., Muller, L. et al. Food price policies improve diet quality while increasing socioeconomic inequalities in nutrition. Int J Behav Nutr Phys Act 11, 66 (2014). https://doi.org/10.1186/1479-5868-11-66

[591] Darmon, N., Drewnowski, A., Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis, Nutrition Reviews, Volume 73, Issue 10, October 2015, Pages 643–660, https://doi.org/10.1093/nutrit/nuv027

[592] http://www.fao.org/fileadmin/user_upload/agn/pdf/Meerman_Aphane_ICN2_FINAL.pdf

revision is expected to reinforce the baseline trends, whereas e.g., an arrow in the opposite direction implies that the achieving the pesticide reduction targets announce in the F2F Strategy would change or reverse those trends. However, no quantitative value is implied (i.e. two arrows do not equate to double the increase or decrease in any given indicator). All the projections represent informed judgement based on the latest available evidence and are therefore subject to uncertainty. However, particular uncertainty in projections (i.e., due to lack of consensus or significant data gap in the evidence base) are denoted by a question mark symbol [?] to support the interpretation of results.

Table 10-12. Summary of development of indicators

Indicators	Baseline	Pesticide related targets in F2F	Justification
Effects on Health			
• **Cost of food**	↓	↑	With a reduction in pesticide use, food production would be expected to decline whilst there is an adjustment period and resultantly food prices would rise.
• **Health-based government initiatives**	–	–	It is unlikely that the government-led initiatives for health interventions in relation to diet and nutrition will be impacted by the pesticide related targets in F2F.
• **Adverse effect on diet and nutrition**	↓	↓	Increases in food prices force people to adjust as consumer purchasing power decreases and this is likely to have a negative impact on household dietary choices and nutrition.

Note: anticipated trends depicted by arrows.
? denotes uncertainty in the projection

Appendix 2: IN DEPTH ASSESSMENT OF THE POLICY ELEMENTS

11. Assessment and comparison of impacts from policy options addressing alignment with pesticide-related targets announced in the Farm to Fork Strategy (F2F targets)

11.1 Introduction

This chapter sections assesses the direct economic costs (provisions as well as, where relevant, the environmental, social, and macroeconomic costs) from policy options to reach the objectives under the group of "alignment the SUD with pesticide-related targets announced in the Farm to Fork Strategy". The general objectives under this group include the following:

- **C1:** Align SUD with F2F targets
- **C2:** Limit use and risks from pesticides, particularly more hazardous ones[593]

Under each general objective, different specific objectives are defined for each of which a number of policy options for reaching those specific objectives are then assessed. Some of these are mutually exclusive while others can be combined to cumulate effects. This is explained further under each general objective.

Under each general objective, the options are ultimately compared based on their impacts, effectiveness and coherence, efficiency and proportionality as well as subsidiarity. The approach to the comparison is presented in Section 6.2.

11.2 Discarded policy options

The following policy option has been part of the discussion on pesticide risk and use reduction but has been discarded during the further process.

Discarded option	Justification
Introduce the requirement for Member States to tax pesticides	The introduction of a tax on pesticides has been a topic of discussion in various Member States and at the EU level. Three Member States (FR, DK and SE) as well as Norway have taxes in place. A case study as part of this study has compared and assessed the existing designs. Under the EU treaties, the introduction of a tax would require a different legal basis than the environmental competences underlying the SUD. Furthermore, the adoption of taxation instruments requires unanimous acceptance in the Council of the EU. Because of these considerations, the option of a pesticide tax has not been combined with the other policy elements and does not form part of this impact assessment.

[593] As defined in footnote 13 of the F2F strategy "*These are plant protection products containing active substances that meet the cut-off criteria as set out in points 3.6.2. to 3.6.5 and 3.8.2 of Annex II to Regulation (EC) No 1107/2009 or are identified as candidates for substitution in accordance with the criteria in point 4 of that Annex*".

11.3 Impact from policy options addressing the alignment of the SUD with pesticide-related targets announced in the Farm to Fork Strategy

11.3.1 Overview

The table overleaf below summarises the options for achieving this objective.

Table 11-1 Policy options for addressing the general objective

General objective	Specific objective	Least ambitious option	Medium ambitious option	Most ambitions option
C1: Align SUD with F2F targets,	• **C1.1:** Define roadmap (incl. monitoring, responsibilities, and governance) towards reaching the F2F targets	• **C1.1.LE.a:** The two F2F targets remain aspirational. The Commission monitors progress at EU and MS level annually; in case of undershooting the expected trajectory of achieving the targets by 2030, linked to NAPs each MS shall submit annually a specific action plan to the Commission on measures that will be taken to get back on track towards achieving the targets by 2030	• **C1.1.ME.a:** The two F2F targets are included in a revised SUD as mandatory targets to be achieved at overall EU level. As part of a tailored "effort-sharing approach" among MS, each MS would set their own tailored reduction targets at national level in order to contribute to achievement of the overall EU target and taking account of their existing national situation and level of progress in reducing the use and risk of pesticides. In case of insufficient progress towards reaching the EU level targets by 2030, the Commission would identify additional elements and steps to be taken to get this progress back on track	• **C1.1.MO.a:** The two F2F targets are included in EU legislation as mandatory targets addressed to MSs to be achieved at overall EU and individual MS levels. Each MS would be expected to achieve the two F2F targets based on their starting position during the reference baseline period

11.3.2 Impact from policy options addressing specific objective C1.1

This section assesses the impacts from the policy options addressing the specific objective "Define roadmap (incl. monitoring, responsibilities, and governance) towards reaching the F2F targets".

The following policy options are assessed:

- **Least ambitions options:**
  - **C1.1.LE.a:** The two F2F targets remain aspirational. The Commission monitors progress at EU and MS level annually; in case of undershooting the expected trajectory of achieving the targets by 2030, linked to NAPs each MS shall submit annually a specific action plan to the Commission on measures that will be taken to get back on track towards achieving the targets by 2030
- **Medium ambitious options**:
  - **C1.1.ME.a:** The two F2F targets are included in a revised SUD as mandatory targets to be achieved at overall EU level. As part of a tailored "effort-sharing approach" among MS, each MS would set their own tailored reduction targets at national level in order to contribute to achievement of the overall EU target and taking account of their existing national situation and level of progress in reducing the use and risk of pesticides. In case of insufficient progress towards reaching the EU level targets by 2030, the Commission would identify additional elements and steps to be taken to get this progress back on track
- **Most ambitious options**:
  - **C1.1.MO.a:** The two F2F targets are included in EU legislation as mandatory targets addressed to MSs to be achieved at overall EU and individual MS levels. Each MS would be expected to achieve the two F2F targets based on their starting position during the reference baseline period

As a general remark, it should be mentioned that the F2F Strategy mainly dedicated to agriculture and food production and therefore it is scope is narrower than the SUD which is also addressing non-agricultural uses of chemical pesticides.

These policy options are closely linked to the F2F strategy pesticide targets. The medium ambitious and most ambitious options build on the rationale of making the F2F targets legally binding through the SUD. Member States would need to define what actions they take to achieve the targets, adapted to the national context, capacity and economic situation.

It is impossible to estimate the direct costs and benefits of these options, since it is not known what actions Member States would take and what supportive measures would accompany the transition towards more sustainable use of pesticides. In addition, the baseline scenario is not possible to establish as discussed in Section 5.1, since the achievement of the targets may be primarily driven by the renewal programme for active substances under Regulation no. 1107/2009.

In the following, lessons from other policy fields are being discussed, followed by a high-level qualitative estimation of impacts for different stakeholders. Chapter 7 above has made an effort to qualitatively estimate the likely indirect impacts of achieving the F2F targets, e.g. what may be the situation in 2030 if the F2F targets are met?

Legally binding targets in other policy fields

In other policy fields similar approaches (legally binding targets) have been successfully implemented and generated promising results. The current EU climate and energy legislation has been developed in several policy packages, notably 2009 and 2018. In 2018, the recast of the RED, RED II (2018/2001/EU), which focuses on the period until 2030, was adopted as part of the EU's energy and climate policy framework towards 2030 and beyond, the Clean Energy Package. The recast directive reflects the higher target for 2030 and takes the approach creating a legally binding target at the EU level.

The RED and the Effort Sharing Regulation are central pieces of these packages and key lessons from their implementation finds that the monitoring and reporting mechanisms are key to ensure and track compliance, which has helped to increase the renewable energy sourced share in the Member States. Second, the ability to collect data that captures progress in an accurate and widely accepted way is determined as a key factor and related to this, the perception of the need to monitor progress in the policy field is an important factor. It is found that effectiveness of the RED to achieve the targets at an intermediate stage has been highest in countries with low initial ambition, while some frontrunner countries have seen high increases in absolute RES capacity[594].

For the SUD, this indicates that legally binding targets could be a useful instrument to initiate efforts in Member States that have so far made little progress towards reducing the risk associated with pesticide use. The experiences and results from RED show that a system of frequent reporting on monitored data would be key to the success of legally binding pesticide reduction targets in the SUD as well. Currently, the information for the calculation for HRI1 (sales data) is submitted annually by Member States, while the National Action Plans generally do not take the form of reporting on progress towards reduction targets, as most Member States (21 out of 27) have not defined such targets[595]. Reporting in the current form or in an adapted format with national progress reports to the EU Commission can be envisaged and would likely play an important role in ensuring successful achievement of the targets.

Here, a key challenge for the inclusion of legally binding targets in the SUD can be found. The Harmonised Risk Indicators (HRIs) and newly established F2F pesticide indicators are relatively easy to monitor based on data on sales of pesticides that has been collected for a long time. However, the use of these risk indicators is contested from different sides. Stakeholders from both pesticide industry and environmental NGOs, as well as Member State authorities express in interviews on the evaluation of the current SUD that the risk indicators, in particular HRI1, are not accurately capturing the sustainability of the use of pesticides.

As a result, reporting on the HRIs or F2F indicators in the context of legally binding targets could be highly contentious, as factors such as volumes of low-risk pesticides or productivity gains in some Member States may lead to misleading HRI1 figures, while the practices around the use of the sold pesticides are not captured in the indicator. This contention does not make the monitoring of targets impossible, but the already existing criticism may be expanded on the developments of (non-) achievement of the targets.

Stakeholder feedback on legally binding targets

The option of legally binding targets in the SUD has been discussed in stakeholder consultations and the views are clearly diverting. Most Member States oppose legally binding targets, arguing that targets are already set in National Action Plans and that setting legally binding targets would go against the subsidiarity principle. They also highlight the need to consider progress made already towards sustainable use of pesticides, not to “punish” good performance (e.g. in an effort sharing approach). Industry stakeholders representing famers, producers and pesticide industry also

[594] For further analysis of RED, see also case study on Additional Measures

[595] European Commission, “On the Experience Gained by Member States on the Implementation of National Targets Established in Their National Action Plans and on Progress in the Implementation of Directive 2009/128/EC on the Sustainable Use of Pesticides,” 2020, https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_sud_report-act_2020_en.pdf. European Commission.

highlight the need to adapt potentially legally binding targets to national contexts and capacity, arguing that quantitative targets based on sales volumes (HRI1) would not adequately reflect risk reduction. Environmental organisations consulted strongly support legally binding targets at EU and national levels, arguing that provisions in the current SUD are too weak and not sufficiently controlled and enforced at Member State level to be effective. Stakeholders across the board highlight the need to adapt targets to the national context and situation as well as progress already made.

11.3.2.1 *Impacts from option C1.1.LE.a*

This policy option would be similar to the baseline situation, in that the two targets outlined in the F2F Strategy remain aspirational and are not put as targets in the legislation. The link between SUD and the F2F targets would be strengthened through a link between the NAP and specific a requirement for Member States to submit a yearly action plan in case the expected targets are not "on track" towards the 2030 deadline.

Direct economic impacts

National Authorities

National Authorities are already reporting development on HRI1 and HRI2 to the Commission on a yearly basis. The F2F targets' indicators are based on similar calculation methods (and the same sales data) and the Commission has elaborated guidance and tools to support the calculation by Member States. Yearly reporting on the F2F indicators, in parallel with the HRIs, would likely only bring minor additional direct costs since the methodology and processes are already in place in all Member States.

Professional pesticide users

There would likely be no additional direct costs for professional pesticide users from this option. It may be that the ambition of Member States will increase, but it is not possible to predict what specific measures may be put in place by Member State authorities to achieve the targets and hence not possible to estimate the direct costs for professional pesticide users.

A discussion on the indirect costs of reaching the F2F targets can be found in Section 10.2.

European institutions

If Member States are required to report yearly on progress and to develop action plans when progress is insufficient, the European Commission would need to follow up by reviewing action plans and monitoring progress on actions. In this sense, there would be a direct additional cost for European institutions, however it is not possible to estimate the magnitude.

Other impacts (environmental, social, macroeconomic)

A discussion on the environmental, social and macroeconomic impacts of reaching the F2F chemical pesticide targets can be found in Chapter 7.

11.3.2.2 *Impacts from option C1.1.ME.a*

Under the medium ambitious option, it is proposed to include the two F2F targets in a revised SUD. The targets would be mandatory to be achieved at an overall EU level. Each Member State would set their own tailored risk, and use reduction targets at national level in order to contribute to achievement of the overall EU target. This would entail considering the existing national situation and level of progress in reducing the use and risk of pesticides since the adoption of SUD. In case of insufficient progress towards reaching the EU level targets by 2030, the Commission would identify additional elements and steps to be taken to get the progress back on track.

Direct economic impacts

National Authorities

National Authorities would have to set targets at a national level. Member States with less risk reduction (as measured by HRI1) would be expected to set higher or stronger targets, whereas Member States with strong risk reduction since the adoption of SUD (as measured by HRI1) would be able to set lower targets. Taken together, the risk reduction at EU level should achieve the F2F pesticide targets.

To achieve the national targets, Member States would need to develop actions in line with the targets set, meaning that in some Member States strong actions would be needed. It is not possible to foresee how Member States would work to achieve the targets set, since this would likely depend on the national context, capacity, economic situation etc. Similarly, support measures would be necessary to facilitate the transition, representing an additional cost to Member States. Since there are a multitude of options available and little clarity on the role of other instruments to support the transition (notably the CAP), the direct costs for Member States to implement tailored targets are not possible to estimate.

There would be additional direct costs for Member States in relation to putting in place data collection and regular reporting on progress, a pre-requisite to enable effective monitoring and enforcement. It is not possible to estimate the costs precisely, but an indication can be derived from the aforementioned RED example, where the median costs is estimated to be 10 309 EUR per Member State and year (resulting in a total of 278 343 EUR) for the policy planning obligation, and a median cost of 4 407 EUR per Member State and year (resulting in a total of 118 989 EUR) for the biennial progress report (the biennial nature of the report needs to be noted, which would lead to a doubling of costs for an annual reporting frequency).

The costs were found to be much higher for all energy-related planning (ca. EUR 6 million per year for all MS) and reporting (ca. EUR 13 million per year for all MS) obligations. In particular, the Energy Efficiency Directive creates much higher planning and reporting costs for Member States because of the higher complexity of data collection and a higher diversity of national approaches to increase energy efficiency. Given the complexity of SUD, this may be a closer and more accurate estimate of what a legally binding option with effort sharing would cost, i.e. a total cost of EUR 19 million per year for all Member States.

Pesticide users

To achieve the tailored target at national level, pesticide users would need to change their use of pesticides. It is likely that farmers and the agricultural sector would carry the largest share of direct cost, given the prevalence of pesticide use and its role in conventional agriculture. The direct costs are not possible to estimate, since the mechanisms to achieve the risk and use reduction would be up to Member States and could take different forms and direct costs may also be offset by support mechanisms.

A discussion on the indirect costs for professional pesticide users can be found in Section 10.2.

European institutions

In an effort sharing approach, the European Commission would need to agree with Member States on performance measures. As discussed earlier, HR1 is not considered a strong indicator and it may have to be considered to develop other indicators to measure progress. The European Commission will also need to define how to distribute the efforts, to ensure reaching the overall targets at EU level. Furthermore, there would be a need to define and develop follow-up measures and penalties in the event of lacking progress towards agreed targets at Member State level. No estimates can be derived from previous studies on costs for the European Commission.

Other impacts (environmental, social, macroeconomic)

A discussion on the environmental, social and macroeconomic impacts reaching the F2F chemical pesticide targets can be found in Chapter 7.

11.3.2.3 *Impacts from option C1.1.MO.a*

In the most ambitious option, the two F2F targets would be included in the revised SUD as mandatory targets, to be achieved at overall EU and individual MS levels. The progress made towards reducing the risk and impacts of pesticides varies between Member States. First Member States have different histories as several of them initiated national or regional programs before the entry into force of the SUD. The variability of ambitions, as translated in the NAPs, also places the Member States at various starting points to achieve the F2F reduction targets as illustrated in the evolution of their national HRI1 and F2F indicators. Achieving a further 50% reduction in Member States that have already considerably reduced the use and risk of chemical pesticides may be difficult and could also be perceived as unfair since it would penalize “good performance”. This point was raised repeatedly by Member States and other stakeholders throughout the consultations, calling for the European Commission to adapt targets to progress already made.

In these options, each MS would be expected to achieve their individual targets by 2030, based on their starting position during the reference baseline period for F2F (2015-2017), and thereby contribute to achieving a 50% risk reduction at EU level. To consider progress made, the indicators used to adapt targets need to be directly related to the use and risk of chemical pesticides and more hazardous pesticides. The indicators available to this end are the HRIs and the F2F pesticide indicators, which although imperfect are the best measures currently available.

It would be possible to modulate the pesticides targets based on the past evolution of the F2F1 and F2F2 - taking into consideration a three-year average, for example average change between 2012-2014 and 2015-2017 (and ultimately 2027-2030 to establish the targets have been met) - as these demonstrate past and current efforts in reducing risk and use of pesticides.

Targets could be adapted based on how close Member States are to the average EU change. Member States that are close to or above (meaning less risk reduction) the EU average would retain the 50% reduction target, whereas Member States that have already made significant progress on risk reduction could have their target adapted to reflect this. If the threshold is set to +/- 20 in deviation from EU average, the F2F1 and the F2F2 the target could be reduced for Member States that show more positive change. Using the same threshold, it could be considered to increase the target for Member States that have not progressed or where the risk has increased significantly. However, it would likely not be seen as realistic by Member States and may not be conducive to incentivizing Member States towards stronger efforts.

As it will be important to have a simple and realistic approach, it could be considered to only have two levels of targets, 50% as indicated in F2F and an adapted target of 25%. With the confidential data available it should be possible to model whether adapting the targets would impede the possibility of achieving the overall EU targets.

While the approach outlined would allow targets to be adapted and progress to be made, there are key considerations that challenge the relevance of adapting targets based on F2F indicators:

- The F2F indicators are indices, based on sales data, and do not relate to volume; rather they only show the change in risk profile of pesticides sold relative to the baseline for the individual Member State. In that sense, comparing the evolution of indicators between Member States is a crude measure and may not reflect the actual risk profile of pesticides sold.

- The evolution of F2F indicators is likely to be driven in part by actions at Member State level and in part by the outcomes of the review program for active substances under Regulation (EC) No 1107/2009. In this sense, the trend in the indicators is not solely related to what Member States can actually influence by their actions.

Direct economic impacts

National Authorities

Member States would need to develop actions to achieve the two (adapted) F2F targets by 2030. It is not possible to foresee how Member States would work to achieve the targets set, since this would likely depend on the national context, capacity, economic situation etc. Similarly, support measures would be necessary to facilitate the transition, representing an additional cost to Member States. In Member States were there has already been a strong progress on risk reduction this option would potentially require strong measures to achieve further reductions in line with F2F (since the baseline is already low) and may facilitate a transition towards organic agriculture, unless the targets are adapted.

In Member States that have not made much progress yet, there will be more room for maneuver to reduce pesticide use and risk. Since there are a multitude of options available and little clarity on the role of other instruments to support the transition (notably the CAP), the direct costs for Member States to implement tailored targets are not possible to estimate. There would likely be additional direct costs for Member States in relation to putting in place data collection and regular reporting on progress, a pre-requisite to enable effective monitoring and enforcement, similar to the medium ambitious option, i.e., a total cost of EUR 19 million per year for all Member States.

Pesticide users

To achieve the tailored target at national level, pesticide users would need to change their use of pesticides. It is likely that farmers and the agricultural sector would carry the largest share of direct cost, given the prevalence of pesticide use and its role in conventional agriculture. The direct costs are not possible to estimate, since the mechanisms to achieve the risk and use reduction would be up to Member States and could take different forms and direct costs may also be offset by support mechanisms.

A discussion on the indirect costs for professional pesticide users can be found in Section 10.2.

European institutions

It is not clear from this option how non-compliance would be sanctioned and what role the European Commission would have to control and enforce the achievement of the F2F targets by 2030. That said, if the targets are applied at EU and Member State level, there would likely be less additional costs compared to the medium option with an effort sharing approach, which would require more governance efforts.

Other impacts (environmental, social, macroeconomic)

A discussion on the environmental, social and macroeconomic impacts reaching the F2F chemical pesticide targets can be found in Chapter 7.

11.3.3 Comparison of options for alignment of the SUD with the F2F targets (specific objective C1)

Table 11-2 addressing the options for alignment of the SUD with the F2F targets

	C1.1.LE.a	C1.1.ME.a	C1.1.MO.a
Impacts			
Professional users	**/** *Direct costs depend on Member State policies*	**- to --** *Direct costs depend on Member State policies* *Decreased productivity of production with high pesticide needs*	**- to --** *Direct costs depend on Member State policies* *Decreased productivity of production with high pesticide needs*
National authorities	**-** *Additional efforts for assess and develop policies and prepare reports on tracked progress*	**- to --** *Policy planning and reporting costs depending on target level for each Member State*	**- to --** *Policy planning and reporting costs depending on starting point of pesticide risk indicator in each Member State*
European Institutions	**/**	**-** *Costs for defining effort sharing distribution and enforcement of penalties in case of missed targets*	**-** *Costs for enforcement in case of slow progress or missed targets*
Other stakeholders	**Pesticide producing industry:/ to -**	**Pesticide producing industry: -** *Reduced sales of pesticides with higher risk profiles*	**Pesticide producing industry: -** *Reduced sales of pesticides with higher risk profiles*
General society (Environmental. social, macroeconomic impacts)	**/**	**/ to +** *Increased food prices but lower pesticide exposure and risks of pesticide poisonings. Partially improved environmental status.*	**/ to +** *Increased food prices but lower pesticide exposure and risks of pesticide poisonings. Partially improved environmental status.*
Other criteria			
Effectiveness	**-** *Likely limited change as action towards ensuring that Member States meet the target remains limited to soft measures*	*Effectiveness depends on the ability and willingness to enforce targets or the buy-in from Member States*	*Effectiveness depends on the ability and willingness to enforce targets or the buy-in from Member States*
Coherence	**-** *Since there is uncertainty on effectiveness, coherence could be limited with regard to the EU's policy objectives on protection of environment and*	+ *Stronger effectiveness assumed, thus also the coherence would increase as compared to C1.1.LE.a*	++ *See C1.1.LE.a and C1.1.MO.a*

	C1.1.LE.a	C1.1.ME.a	C1.1.MO.a
	health, as well as level economic playing fields. *Also, potentially limited coherence with other strategies, in particular Farm to Fork strategy and Biodiversity strategy*		
Efficiency	**-** *Limits to the effectiveness of the current SUD would likely persist, likely falling short of the relevance of the issue and the EU targets*	**+** *Building on past achievements or other criteria for effort sharing likely favours cost efficiency in reduction measures to be taken*	**-** *Requiring the same reduction from all Member States likely does not favour least costly reduction measures across the EU*
Proportionality	*No changes expected due to limited effectiveness*	*No issues*	*There might be proportionality issues given that the baseline of current use of pesticides varies widely between MS.* *Also, in order to ensure proportionality, the differences between the agricultural sectors in the MS should be taken into account.*
Subsidiarity	*No issues*	*No issues, precedence in policy areas such as renewable energy policy*	*The subsidiarity of a fixed reduction target for all Member States would need to be assessed based on the exact proposal for such an option.*

/: no impact
Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)
():brackets if costs, benefits etc. are only potentially
If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +
The green coloured cells pertain to the preferred option of the Commission

11.4 Impact from policy options aimed at limiting the use and risks from pesticides, particularly more hazardous ones

11.4.1 Overview

The table overleaf below summarises the options for achieving this objective.

Table 11-3 Policy options for addressing the general objective

General objective	Specific objective	Least ambitious option	Medium ambitious option	Most ambitions option
C2: Limit use and risks from pesticides, particularly more hazardous ones[596]	• **C2.1:** Increase ambition towards reaching F2F target on reducing use of more hazardous pesticides	• **C2.1.LE.a:** Prohibit purchase and use of more hazardous pesticides by non-professional users (e.g. for them to be used the person would need to be trained)	• *Least ambitious option + the below* • **C2.1.ME.a:** A prescription system for the purchase by professional users of more hazardous pesticides • **C2.1.ME.b:** Prohibit use of more hazardous pesticides in sensitive areas such as urban green areas	• *C2.1.ME.a + the below* • **C2.1.MO.a:** Legal provisions to prohibit the use of **all chemical pesticides** in sensitive areas such as urban green areas as per ambition of Biodiversity Strategy

[596] As defined in footnote 13 of the F2F strategy "*These are plant protection products containing active substances that meet the cut-off criteria as set out in points 3.6.2. to 3.6.5 and 3.8.2 of Annex II to Regulation (EC) No 1107/2009 or are identified as candidates for substitution in accordance with the criteria in point 4 of that Annex*".

11.4.2 Impact from policy options addressing specific objective C2.1

This section assesses the impacts from the policy options addressing the specific objective "Increase ambition towards reaching F2F target on reducing use of more hazardous pesticides".

The following policy options are assessed:

- **Least ambitions options:**
  - **C2.1.LE.a:** Prohibit purchase and use of more hazardous pesticides by non-professional users (e.g. for them to be used the person would need to be trained)
- **Medium ambitious options**:
  - **C2.1.ME.a:** C2.1.LE.a + A prescription system for the purchase by professional users of more hazardous pesticides
  - **C2.1.ME.b:** C2.1.LE.a + Prohibit use of more hazardous pesticides in sensitive areas such as urban green areas
- **Most ambitious options**:
  - **C2.1.MO.a:** C2.1.ME.a + Legal provisions to prohibit the use of all chemical pesticides in sensitive areas such as urban green areas as per ambition of Biodiversity Strategy

Stakeholder feedback on increasing ambition towards reaching F2F target on reducing use of more hazardous pesticides

Feedback from Member State authorities outlined the importance of working towards the prohibition of more hazardous pesticides, specifically in sensitive areas. However, there was differing views with regards to the option on a possible prescription system for the purchase of more hazardous pesticides by professional users. Overall, 10 Member States were of the view that this approach would not be feasible and/or have an impact on a reduction in the use of more hazardous pesticides. Out of the 10 Member States, five noted that the implementation of this option would impose significant administrative burden for both National Authorities and PPP users. Seven Member States were of the view that a prescription system could work, while a small number of Member States noted that it may be better implemented under Regulation 1107/2009.

From the perspective of environmental NGO's and civil society organisations, there is a strong view that prohibiting the use of all (or a large proportion) of hazardous pesticides would lead to a reduced use and risk of chemical pesticides in line with the F2F targets (20 out of 22 of respondents to the targeted survey answering to a major extent). This was seen to be particularly the case for limiting the use of hazardous pesticides in sensitive areas and for non-professional users. The implications of this were primarily seen to have an impact on environmental sustainability in the EU, water quality and quality of food production within the EU. By contrast, for PPP users and respective industries, the prohibition of more or all hazardous pesticides was seen to have an impact to a lesser extent (68 out of 151 of respondents to the targeted survey answering to a major/ moderate extent). Through the implementation of the F2F targets, it was expected by users and PPP industry that the greatest impact would be observed in relation to food prices for EU consumers, production/ manufacturing costs and innovation and technological development of alternative methods to control pests.

11.4.2.1 Impacts from option C2.1.LE.a

This option would require that any person buying or using more hazardous pesticides to undergo training. It is assumed this training would be the same or similar to the training for professional users under the current SUD and that trained users would be certified. Likely, control of the requirement would take place at the place of purchase, essentially leading to a ban of non-professional use of more hazardous pesticides.

In several Member States, such limitations on the purchase of more hazardous substances are already in place. This is the case in differing formats in Belgium, Cyprus, France, Greece, Hungary, Ireland, Malta, Sweden, and foreseen in draft legislation in Luxembourg. For these Member States, minor changes of legislation and thus of impacts could be expected, while for Member States that do not have training obligations for the purchase of more hazardous substances, more substantial impacts can be expected.

Direct economic impacts

The first economic impact relates to Member State’s authorities responsible for controlling and enforcing the requirements. Such controls are already necessary for the training requirements for professional users. Primary point of enforcement could be the selling points for more hazardous substances. The highly distributed landscape of non-professional users and selling points (e.g. through e-commerce), could represent a high complexity for controls. However, most of these points of sales need to be controlled under current requirements already. Therefore, additional costs for Member State authorities can be expected to be relatively low, even though the enlarged scope of a control visit would increase costs to some extent.

The second relevant economic impact arises for non-professional users, who would have to be trained in order to still be allowed to apply more hazardous pesticides. However, there is little to no data on the number of non-professional users or the amounts and types of pesticides they use. Therefore, a quantification of the costs cannot be made. The costs would however be driven by the training costs which currently vary by Member State between free training and fees of several hundred euros in a few Member States. Additionally, the costs for pest and weed control for non-trained users can be expected to increase.

A third economic impact would be the reduction of sales of more hazardous pesticides to non-professional users, which impacts the pesticide producing industry. However, sales of less hazardous pesticides and alternative methods can be expected to increase with benefits for producers of such products.

Other impacts (environmental, social, macroeconomic)

A training requirement for the use of more hazardous pesticides can be expected to improve the respect of condition of use of such pesticides and better inform non-professional users about risks and alternatives. As a result, health and environmental impacts could be reduced by such a measure. This is also reflected in the responses from NGOs to the targeted survey, of which 70%[597] expect reductions of use and risk to a major extent. Increased barriers to more hazardous substances in non-professional use could lead to a shift in attitude towards pest and weed control in non-professional areas which reduces the use in such fields with lasting effects.

Similar to the economic impacts of the measure, a quantification of the health and environmental impacts is not possible because of the limited data availability on non-professional uses.

11.4.2.2 *Impacts from option C2.1.ME.a*

A prescription system for the purchase of more hazardous substances would add a requirement for the use of such substances by professional users. This creates economic impacts on users and those

[597] 16 out of 23 respondents

issuing the prescription system. The setup of a prescription system can vary with the competence to issue prescription assigned to different possible actors.

In the EU and EFTA, three countries – Greece, Hungary and Switzerland – have prescription systems for pesticides in place. These systems and their different features are analysed and described in the accompanying case study to this report. For this impact assessment of a pesticide prescription system, the Hungarian system is used as a reference as it come closest to the formulation of the policy option to require a prescription for the purchase[598] of more hazardous substances[599].

Direct economic impacts

Professional users

In the system in place in Hungary, farmers are required to have a service contract with a plant doctor or comparably trained service provider that follows and monitors the pest occurrence on the land of the farmer. The prices for these are based on hectares and are estimated by the interviewee to lie between EUR 9 and 18 per hectare and year. Because of the differences in organisation of advisors between the Member States, it is difficult to assess how many new contracts would have to be signed and which existing farmer-advisor relationships can be used for obtaining prescriptions. In particular, large farms can be assumed to rely on expert input into the pesticide management. This assessment therefore assumes that farmers with more than 100 ha can use existing advisory services. This covers roughly 50% of the EU's UAA[600]. However, a price increase for advisory services can also be expected. This is assumed to be 25% of the price per ha indicated above, based on an assumed increase in interactions with farmers to issue prescriptions.

The ultimate costs of such a system depend on the need for new advisory contracts and the farm size, for which the structures differ substantially across the EU. While farms in Northern and Western Europe as well as Czechia and Slovakia tend to be larger in area, farms in Southern and Eastern Europe are often smaller in this respect. In all Member States, a higher number of small farms results in a low farm size average, while large parts of the land are owned by relatively few large farms[601].

The requirement for a subscription could also only be applied to candidates for substitution (CfS) to limit the impacts from the special risk properties of these substances. Initially however, it cannot be expected that such a reduced applicability would lead to lower costs. These substances are widely used, and professional users can be expected to maintain the option of applying them in case of need to protect their yields and remain competitive in respect to other producers. In the long term, however, the list of candidates for substitution could become shorter with the re-approval dates for many of them falling between 2021 and 2026. Then the costs could become lower as less and less users require the remaining CfS.

[598] in contrast to Switzerland, where the use of pesticides needs the prescription

[599] in contrast to Greece, where all pesticides require a prescription for professional users

[600] Eurostat. 2016. Farms and farmland in the European Union – statistics. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics

[601] Ibid.

Table 4. Estimations of costs

Name	Type	Assumptions	Costs	Distributional considerations
Procurement of plant doctor advisory services	Recurring annually	• It is assumed that for 50% of the EU's UAA new advisory contracts are needed, while for the other 50% of UAA the price for existing services increases by 25%. • Based on the Hungarian prescription system, the price per ha is assumed to be between 9 and 18 EUR.	Approximately between EUR 880 million and EUR 1.7 billion	• In the assumed scenario, farmers with no existing advisor relations (which can be assumed to be smaller and part-time farmers) would face higher additional costs than ones with existing relations (presumably larger, highly professional ones).

National authorities

Authorities bear costs in the prescription assumed above for controls of pesticide users, advisors and distributors on the compliance with the prescription requirements. However, the prescription controls are part of a large number of tasks that also involve sampling and pesticide application equipment inspections. Therefore, the specific costs of the controls for prescriptions cannot be estimated.

Additionally, a cost for authorities would be the set-up of a reporting to which all prescriptions and their use are inserted. An assessment of costs from processing reported data is provided in Table 13-3 in Section 13.3.2.1. The costs reported by Member States vary significantly but can overall be expected to be between 100 000 EUR and 200 000 EUR per Member State.

A different system can be envisaged, in which prescriptions are issued by public bodies rather than plant doctors of the private sector. Such a system is in place in Switzerland. The costs would then potentially shift from users to public authorities, which are responsible for pest monitoring as a basis for prescriptions.

Other stakeholders

Plant doctors offering the advice and prescription service would see benefits equal to the costs for professional users. For this, they would be subject to controls of the prescription issued, which entails additional costs for record keeping and availability for controls. However, the general economic impact would be positive.

If prescriptions change the risk profile of purchased and used pesticides, producers of pesticides would also be impacted in the sales of their products. This effect is however highly uncertain (see the discussion of other impacts below) and therefore impossible to quantify.

Furthermore, sellers and distributors of pesticides would need additional time for checking that the correct prescription is provided at the time of purchase.

Other impacts (environmental, social, macroeconomic)

The key rationale of a prescription system would be to require justification from the user for applying certain more hazardous active substances in specific situations and thus reducing the overall risk to the environment and human health. In this theory, the impacts on the health of users, the general public and the environment would therefore be improved.

In practice, however, there is no conclusive evidence of a use reduction of such substances caused by the prescription requirement. A reduction in the number of prescriptions issued or clear trends in the risk profile of pesticides used could not be observed in Hungary or the other two countries with a prescription system in place. A key factor is that when pests are identified by monitoring services of qualified advisors or plant doctors, an effective treatment will be prescribed in order to secure yields. At this stage, preventive or alternative measures in line with IPM principles will not be possible anymore. A central question in this respect is the liability of plant doctors as prescribers for potential yield quality or quantity losses as decisions are transferred but related risks of losses remain with the producer. In a system with many independent prescribers, a change to one with less restricted issuance of prescriptions would remain an option if revenue losses were perceived by the producer.

As such, the case study on existing prescription systems, which describes these effects, concludes that sensitisation of users is the major effect, but no change in the use profile can be linked to the instrument. The application of the substances remains largely possible and normal pest pressures justify prescriptions in the majority of cases, at least in the short to medium term. Still, sensitisation could effectively lead to fewer needs for prescriptions and thus reduced risks in the long term.

Another impact can be expected to the timing of purchases that may require a change of logistical systems. In particular, large farms tend to purchase pesticides for a season in bulk at specific times of the cropping season based on the crops and their predicted pesticide needs, not needs based on monitoring. If a prescription is needed, this means that purchases can only be made after the monitoring reveals a threat. While this has the intention and potentially benefit of reducing the upfront reliance and dependency on pesticides, logistics may initially be a challenge for farmers and distributors.

A prescription system only on CfS would not affect these impacts to a large extent. As long as those substances are approved in the EU, their use could be justified for a prescription. A substantial use or risk reduction would therefore only occur because of changes in the approval situation, related to the implementation of Regulation No. 1107/2009.

11.4.2.3 *Impacts from option C2.1.ME.b*

The restriction of use of more hazardous substances in certain areas is a potential option to decrease the use of pesticides while increasing the protection of human health and biodiversity in those specific areas. The main determining factor for the impact of this option is the definition of sensitive areas and urban green areas.

Under Article 12, Member States are already required to ensure that the use of pesticides is minimized or prohibited in areas used by the general public and vulnerable groups, Natura 2000 areas as defined by Directive 2000/60/EC, and areas recently treated that are used or accessible to agricultural workers. However, in the targeted survey, only seven Member States indicated to have measures in place for the minimization of risk and recording of information on the use of pesticides in public areas. The Natura 2000 network covers 18% of the land area of the EU, 40% of which are agricultural land[602]. Besides the existing Natura 2000 areas, the definition of sensitive areas is also meant to include other national regional and local protected areas in the ambition to

[602] European Commission, “Farming for Natura 2000” (Luxembourg: Publications Office of the European Union, 2018), https://doi.org/10.2779/85823.

legally protect at least 30% of the EU's land area, as formulated in the 2030 Biodiversity Strategy[603]. Therefore, this area is assumed to be protected in 2030.

In addition to sensitive natural areas, urban green spaces are defined here as all publicly owned green spaces, frequently publicly visited. This includes playgrounds, parks, school yards and urban roadside greenery.

Direct economic impacts

Professional users

The restriction to not allow the use of more hazardous substances in sensitive areas including urban green areas can be expected to lead to higher costs for pest and weed management for the users maintaining or cultivating these areas.

Considering the target of the 2030 Biodiversity Strategy, 47 million ha of utilized agricultural area (UAA) are assumed to have a legal protection status in 2030 across the EU. Even though some of these areas are likely already under organic or low-pesticide input production, higher costs for farmers can be assumed. The economic impacts of low-pesticide production on the larger scale have been presented and discussed in Section 10.2.2. Costs and benefits of low pesticide input on sensitive areas as a part of the EU's UAA are highly context dependent and therefore impossible to estimate. The costs would depend on the type of use of the areas, between grassland and crop production, the specific crop, climate, and other factors. As an overall approximation, the higher the production intensity of the previous use, the higher the use of more hazardous substances can be assumed, and therefore the higher the costs for adaptation in a sensitive area will be. As discussed in Section 10.2.2, some studies concluded that pesticide reduction without productivity loss is possible at the field level, and other findings stress the risk for loss of yields in such a scenario. In general, costs for professional users – both in terms of higher production costs and lower yields – can be expected for sensitive areas currently under intensive use in the short term, while in the long-term investments in e.g. physical weed control equipment will be depreciated and lower the overall costs. However, smaller farmers with less ability to invest in alternative solutions in the short term are likely to be affected more strongly than larger farmers. With the substantial share of EU land under some form of protection in 2030, the overall direct costs for professional users would be significant.

Public authorities

The restriction of use in urban public areas mainly affects public bodies in their practices and spending on managing these areas. Six Member States[604] report in the targeted survey that they would see no impact as more hazardous substances are not used in parks, sport, school and recreational grounds. The other Member States expect increased costs of pest and weed management by other available means. However, several Member States also report that the use of pesticides in public urban areas is minor, which means that also costs can be expected to be relatively small. A study on a selection of French municipalities[605] found that costs for the management of green spaces increase in the first phase of a zero-pesticide management, but fall

[603] European Commission, "EU Biodiversity Strategy for 2030."

[604] Denmark, Netherlands, Slovenia, Sweden, Greece, Belgium

[605] Helene Cheval and Pauline Laille, "CONDITIONS TECHNICO-ECONOMIQUES DU PASSAGE AU « ZERO PHYTO »" (Plante & Cité, Syrphea Conseil., 2017), https://www.plante-et-cite.fr/ressource/fiche/441/conditions_technico_economiques_du/n:24.

after adjustments to the management approach have been made. This underlines the economic feasibility of restricting the use of more hazardous pesticides in urban green areas.

Other impacts (environmental, social, macroeconomic)

As mentioned above, pesticides used in urban green areas are relatively low, and therefore have little contribution to overall risk as calculated by HRI1 or the F2F indicator 1. However, the exposure of the general public and vulnerable groups such as children is often higher if pesticides are applied in e.g. playgrounds, school yards or other recreational areas is likely higher than in large agricultural areas. These health benefits are reported by Member State representatives, NGO respondents and users in their survey responses. Seven Member States out of 12 responding to this question see relevant human health benefits; 70% of NGOs expect major risk reductions from this measure and 55% of user respondents expect major or moderate improvements in risk. Based on this agreement, a strong benefit for human health can be expected, while the low volumes mean that environmental impacts and EU indicators would likely not be impacted substantially.

Conversely, the restriction of use in sensitive natural areas would primarily have environmental benefits as habitats and species would be protected from one pressure. Section 7.2 outlines the overall impacts of reducing pesticide use and risk. The effects would be rather local to the sensitive areas but would relieve the pressures from hazardous chemicals in areas with high ecological value and legal protection status.

11.4.2.4 *Impacts from option C2.1.MO.a*

This policy option is largely similar to the one discussed above (Section 11.4.2.3) and only differs in the extent to which pesticide use is prohibited in the specified areas. In this option, no pesticides can be used in sensitive areas or urban green areas. This ambition is defined in the 2030 Biodiversity Strategy as one key commitment to the restoration of the EU's nature.

The types of impacts are also similar to the ones discussed above. However, the magnitude can be expected to be substantially higher, as the ban of all chemical pesticides reduces the available options for crop protection more severely than the ban of more hazardous substances in the previous option.

Direct economic impacts

Professional users

Again, the restrictions on legally protected areas can be expected to cause strong impacts on farmers producing on land that falls within these areas. However, in the case of zero pesticide use on the 30% of protected land areas, agricultural production will be highly limited and the remaining practices significantly more costly. A study for the EU Parliament[606] compares the costs of non-pesticide options for pest and weed management. Mechanical control of weeds creates substantial upfront investment costs as well as recurring operating costs of up to 1 500 EUR per ha. Biocontrol mechanisms can target other pests as well but are estimated to be between 100 and upwards of 600 EUR per ha. Their target pests also do not cover the full range of pests, which would leave crops unprotected to certain conditions. The high economic impact is also mentioned in Section

[606] European Parliamentary Research Service, "Cost of Crop Protection Measures" (Brussels: European Union, 2021), https://doi.org/10.2861/67868.

10.2.2, with research finding that crop production in the EU without chemical pesticides is not currently realistic[607].

The overall costs of such an option depend on the area that would have to transition from pesticide use production to non-pesticide use but considering the important area of land to be protected in 2030, the cost can be expected to be substantial, with strong limitations for smaller farmers with less ability for investments.

Public authorities

Similar to the above, costs for public authorities are linked to the management of the public urban green spaces. The costs would also increase in the short term and even stronger than for option C2.1.ME.b (see Section 11.4.2.3) because no chemical pesticides would be possible to use. This impact is mentioned by many Member States in the targeted survey, except for those in which a complete ban on urban green areas is already in place[608]. On the other hand, insights provided by the Netherlands to the survey as well as the French Plant&Cite study[609] report that zero-pesticide use in public areas is possible without creating high-cost burdens for municipalities. However, this can only be expected in the long term.

Other impacts (environmental, social, macroeconomic)

A complete ban of chemical pesticides in sensitive areas including urban green areas would amplify the health and environmental benefits discussed above. In the urban context, improvement of the environmental status of green spaces would avoid the risk of accidental chemical contamination from pesticides for the public, particularly for vulnerable groups such as children. NGO respondents to the targeted survey expect this option to lead to major reduction in risk[610], which is largely supported by user respondents[611]. However, three Member State respondents express concerns about the control of invasive species and new pests, if no control substances are available.

Similarly, the environmental benefits from banning the use of chemical pesticides in protected areas would be of higher amplitude than in the previous option. A complete avoidance of chemical pesticides would likely be linked to a change in land management, and relieve chemical pressures. It can therefore be expected to provide important benefits on water quality, biodiversity and soil quality, as assessed in Section 7.2.

As a loss of yield from the areas under protection is very likely and since the share of land at 30% substantial (even though not all this land will be agricultural land), reduced EU food production can be expected. This will impact the EU's trade balance of food products, with a need for more imports from third countries. These impacts are further assessed in Section 10.2.5.

11.4.3 Comparison of options for limiting the use and risks from pesticides, particularly more hazardous ones (specific objective C2)

[607] European Parliament, "Farming without Plant Protection Products" (Brussels: Euroepan Union, 2019), https://op.europa.eu/en/publication-detail/-/publication/793709ec-8e62-11e9-9369-01aa75ed71a1/language-en.

[608] Luxembourg, Belgium, Netherlands in part

[609] Cheval and Laille, "CONDITIONS TECHNICO-ECONOMIQUES DU PASSAGE AU « ZERO PHYTO »."

[610] 90% (20 out of 22) of NGO respondents answer "to a major extent", while the remaining 2 answer "to a moderate extent"

[611] 33% (44 out of 131) of user respondents answer "to a major extent", 31% (31/131) answer "to a moderate extent", 25% (34/131) answer "to a minor extent" and 9% "not at all"

Table 11-5 addressing options for limiting the use and risks from pesticides, particularly more hazardous ones (specific objective C2)

	C2.1.LE.a	C2.1.ME.a	C2.1.ME.b	C2.1.MO.a
Impacts				
Professional users	**/**	**-- to ---** *High costs for subscribing to pest monitoring services*	**- to --** *Reduced yields from areas with legal protection status*	**-- to ---** *Strongly reduced yields from areas with legal protection status*
National authorities	**Costs for controlling and enforcement: - to --**	**Costs for controlling and enforcement: -**	**Public authorities: -** Increased costs for management of urban green areas	**Public authorities: --** Increased costs for management of urban green areas
European Institutions	**/**	**/**	**/**	**/**
Other stakeholders	**Non-professional pesticide users: --** Increased costs for being able to apply more hazardous pesticides. **Pesticide producers: -** Decrease of sales of more hazardous pesticides to non-professional users, low share overall	**Providers of pest monitoring: ++** Increased demand and needs for their services	**Pesticide producers: /** Shift in pesticide demand for protected areas and urban green areas from more hazardous substances to less hazardous ones.	**Pesticide producers: --** Demand for chemical pesticides in protected and urban green areas disappears
General society (Environmental. social, macroeconomic impacts)	**+ to ++** *Reduce the untrained handling of more hazardous pesticides with benefits to human exposure and respect of the conditions of use*	**/ to +** *Likely little change in pesticide use and risk in the short term as pesticides are prescribed in case of pests*	**+** Reduced exposure of vulnerable groups and ecologically valuable areas to more hazardous pesticides	**++** Strongly reduced exposure of vulnerable groups and ecologically valuable areas to chemical pesticides
Other criteria				
Effectiveness	**+ to ++** *Relatively low volumes but high likelihood of human exposure leading to health benefits and*	**/ to +** *Likely little change in pesticide use and risk*	**++**	**+++**

	C2.1.LE.a	C2.1.ME.a	C2.1.ME.b	C2.1.MO.a
	small reductions in environmental risks	*Enables better data collection on occurrence of pests and the main control mechanisms*	*Reduction of use and risk of more hazardous pesticides in areas of increased concern*	*Strong reduction of use and risk of all chemical pesticides in areas of increased concern*
Coherence	*No coherence issues*	*No coherence issues*	*No coherence issues*	*No coherence issues*
Efficiency	**+ to ++** *Training for the use of more hazardous substances aligns requirements for non-professional and professional users. Effective controls could be challenging due to the diverse types of non-professional users and no register for such users.*	**--** *High costs for professional users while change in pesticide use and risk is likely to be minimal*	**++** *Protection of valuable areas and vulnerable populations from exposure to more hazardous substances justifies costs for users*	**+** *High restrictions on farmers operating in areas with protection status, but also strong pesticide use and risk reduction in those areas*
Proportionaility	**+++**	**+++**	**+++**	**+++** *(albeit dependent on the exact proposal for such an option and the extent to which different areas are considered "sensitive")*
Subsidiarity	No issues	*The subsidiarity of a prescription system would need to be assessed based on the exact proposal for such an option.*	*The subsidiarity of a ban of more hazardous pesticides in certain areas would need to be assessed based on the exact proposal for such an option.*	*The subsidiarity of a ban of all pesticides in certain areas would need to be assessed based on the exact proposal for such an option.*

/: no impact
Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)
():brackets if costs, benefits etc. are only potentially
If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +
The green coloured cells pertain to the preferred option of the Commission

12. Assessment and comparison of impacts from policy options strengthening current SUD provisions

12.1 Introduction

This chapter sections assesses the direct economic costs (provisions as well as, where relevant, the environmental, social, and macroeconomic costs) from policy options to reach the objectives under the group of "strengthening current provisions". The specific objectives under this group include the following:

- **A1:** Improve practical implementation and operationalisation of IPM principles to reduce the use and risk of pesticides and promote alternatives to pesticides
- **A2:** Improve controls and apply harmonised standards
- **A3:** Strengthen effectiveness of the NAPs
- **A4:** Improve expertise of pesticide users

Under each specific objective, several operational objectives are defined for each of which a number of policy options for reaching those operational objectives are then assessed. Some of these are mutually exclusive while others can be combined to cumulate effects. This is explained further under each specific objective.

Under each objective, the options are ultimately compared based on their impacts, effectiveness and coherence, efficiency and proportionality as well as subsidiarity. The approach to the comparison is presented in Section 6.2.

12.2 Discarded policy options

Discarded option	Justification
Colour-coded labelling of pesticides to reflect their hazard profile, e.g. in a traffic light system	No indication this is an issue or problem that needs to be addressed.
Strengthened provisions on the collection and recycling of pesticide containers or packaging	No indication this is an issue or problem that needs to be addressed.
Require the testing of new pesticide application equipment prior to the sale	Not legally feasible
Delete the requirement for Member States to develop NAPs	Not seen as conducive to better implementation, not supported by Member States

12.3 Impact from policy options addressing the limited operationalisation of IPM principles (specific objective A1)

12.3.1 Overview

The table overleaf below summarises the options for achieving this objective.

Table 12-1 Policy options for addressing the specific objective

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitious option
A1: Improve practical implementation and operationalisation of IPM principles to reduce the use and risk of pesticides[612] and promote alternatives to pesticides	• **A1.1**: Improve measurability and monitoring of implementation of IPM	• [...]	• **A1.1.ME.a**: Establish mandatory common framework for electronic IPM record keeping by professional users[613]; require that those records be transmitted on an annual basis to both MS CAs and the Commission (potential links could be established with e.g.: FSDN[614])	• *Medium ambitious option + the below* • **A1.1.MO.a**: Use mandatory crop-specific IPM standards as a basis for controls and enforcement, using penalties and other remedial measures including under the OCR[615].
	• **A1.2**: Operationalise IPM principles for different contexts and crops	• **A1.2.LE.a**: Current IPM principles in annex to SUD clarified and reworded (including potential new technologies which can promote the application of IPM principles) • **A1.2.LE.b**: Requirement for MS to establish tailored IPM guidance (region/crop specific) representing crops covering at least 90% of UAA	• [...]	
	• **A1.3**: Improve implementation of obligation to create incentives / compensation for farmers for using IPM	• **A1.3.LE.a**: Further emphasise the current SUD compulsory requirement for MS to introduce incentives for the use of non-chemical pest control alternatives and methods as well as for any IPM measure that may lead to economic losses for farmers (e.g. crop rotation)	• [...]	• [...]

612 The term "pesticides" is intended to generally signify plant protection products for the purpose of this initiative and biocides are generally excluded from the scope of the work.

613 The record-keeping could take the form of a decision tree based on IPM pyramid including pest/economic injury thresholds as applicable. 'is a certain tool feasible: yes, no, if not, why not?' Justification and evidence for this and then move to the next decision step in the pyramid

614 FSDN scheduled to be adopted in Q2 2022. See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12951-Conversion-to-a-Farm-Sustainability-Data-Network-FSDN-_en

615 Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products,

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitious option
	• **A1.4**: Ensure that advisory services can provide robust advice on IPM	• **A1.4.LE.a**: Introduce a legal requirement for more detailed training and holding of a relevant certificate for all advisors	• *Least ambitious option + the below* • **A1.4.ME.a**: Strengthened role and rules for independent advisory service to professional pesticide users (decoupled from economic interest of selling pesticides and PAE), including link to possible prescription system/obligatory advice	• […]

12.3.2 Impact from policy options addressing operational objective A1.1

This section assesses the impacts from the policy options addressing the operational objective "Improve measurability and monitoring of implementation of IPM".

The following policy options are assessed:

- **Least ambitions options:**
  - n/a
- **Medium ambitious options**:
  - **A1.1.ME.a**: Establish mandatory common framework for electronic IPM record keeping by professional users and require that those records be transmitted on an annual basis to both MS CAs and the Commission (potential links could be established with e.g.: FSDN)
- **Most ambitious options**:
  - **A1.1.MO.a**: A1.1.ME.a + Use mandatory crop-specific IPM standards as a basis for controls and enforcement, using penalties and other remedial measures including under the OCR.

Stakeholder opinions on improving measurability and monitoring of implementation of IPM

From the national authority perspective, Member States were largely of the view that the introduction of electronic IPM record keeping would help to improve measurability and monitoring of implementation of IPM (11 out 27 Member States). For Member States which were not in favour of IPM record keeping (5 Member States), a recurring point was for IPM to be further defined and guidelines enhanced to make sure that IPM is effectively up taken across all Member States.

Other stakeholders see different priorities in respect to the potential change of IPM provisions in the SUD. Professional users and pesticide producers call for limiting the administrative burden of IPM record keeping and stress that implementation is far reaching already thanks to guidance documents, trainings and research findings. However, users and PPP industry also see the benefits of increased data availability to highlight the progress – if the administrative burden of these activities can be limited. Environmental organisations and industries affected by high pesticide use describe a high need for enforcement of the current provisions from Member States towards professional users and from the Commission towards Member States.

12.3.2.1 Impacts from option A1.1.ME.a

Direct economic impacts

The results from the survey with national authorities suggest that no country so far has a mandatory electronic IPM record keeping in place. Only one country has a system for voluntary record-keeping on IPM in place (Finland). Another country (Denmark) has a system in which they require farmers to answer questions regarding IPM; however, this data is not collected by the authorities.

Thus, given that such a system would be new in all countries, it would entail one-off costs for creating the system and then costs for maintaining it. Costs would accrue for professional users, national authorities, and the EU institutions.

Professional users

Professional users of pesticides under this policy option includes farmers but excludes other professional users. According to the latest available data,[616] in total there are around 10.3 million farms in the countries covered by the SUD, which include the EU Member States as well as Iceland, Liechtenstein, and Norway[617]. The numbers per country are presented in the table below.

Table 12-2 Number of farms per country

Country	Number of farms	Country	Number of farms	Country	Number of farms
Austria	132,500	Germany	276,120	Netherlands	55,680
Belgium	36,890	Greece	684,950	Norway	no data
Bulgaria	202,720	Hungary	430,000	Poland	1,410,700
Croatia	134,460	Iceland	no data	Portugal	258,980
Cyprus	34,940	Ireland	137,560	Romania	3,422,030
Czechia	26,520	Italy	1,145,710	Slovakia	25,660
Denmark	35,050	Latvia	69,930	Slovenia	69,900
Estonia	16,700	Lithuania	150,320	Spain	945,020
Finland	49,710	Luxembourg	1,970	Sweden	62,940
France	456,520	Malta	9,310		

Source: 2016 Farm Structure Survey

As can be seen, there are large differences in the number of farms which translate into different overall costs per country for policy options. This should be understood as context for the subsequent assessment of costs.

It can be expected that farmers face one-off costs for creating the necessary infrastructure as well as returning costs for the report keeping and reporting. Their expected costs are summarised in the table below. Qualitatively, results from the targeted survey to users of PPPs and industry found division in the impact that electronic IPM record keeping would have on reducing the risk and use of pesticides, in line with the Farm to Fork targets (17 out of 50 answering that it would have an impact and 20 out of 50 answering that its impact would only be minor).

Table 12-3 Overview of quantitative estimations of costs for professional users

Name	Type	Assumptions	Costs	Distributional considerations
Buying equipment	One-off	• It is assumed that farmers need a computer for recording and submitting the data. No data is available on the number of farmers that already have a computer. Thus, it is assumed that the share of farmers owning a computer is equal to the share of the general population (households) having a computer which is in the EU 27 at	Approx. EUR 278 million (per farmer on average EUR 27)	• Costs are per farm so countries with more farms (e.g., Italy, Poland or Romania) face overall higher costs • Older farmers are more likely to have to buy a computer

[616] 2016 Farm Structure Survey. See: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ef_m_farmang&lang=en

[617] The latter three countries are the countries of the European Free Trade Association (EFTA) (Iceland, Liechtenstein and Norway; excluding Switzerland); together with the EU countries they form the European Economic Area, abbreviated as EEA.

Name	Type	Assumptions	Costs	Distributional considerations
		around 91 %.[618] It is thus assumed that 10% of all farmers would need to buy one. • It is assumed that a computer (desktop or laptop) costs on average 300 EUR • It is assumed that no software needs to be bought		
Time for recording IPM practices	Recurring annually	• The eventual properties of the framework (e.g. level of detail) play a crucial role in assessing how much time is needed. As suggested in the policy option, it is assumed that the framework could take the form of a decision making tree[619]. • It is assumed that on average a farmer would have to spend around 6h[620] per year on recording (and transmitting) decisions in such a framework. • An average hourly labour cost[621] of 12 EUR is assumed[622]	Approx. EUR 742 million annually (per farmer on average EUR 72)	• Labour costs differ between countries • Large differences in time spent between types of farms (mainly dependent on number of lots and diversity of crops)

Source: Own elaboration

The items presented in the table above are additional administrative costs compared to the baseline. Through the survey with national authorities the two mentioned items were also frequently highlighted as additional administrative cost.

National authorities

Costs for national authorities depend heavily on how the data collection will eventually be organised. For the cost assessment is assumed that data collection will be done as part of the upcoming Farm Sustainability Data Network (FSDN), as specificized in the policy option, and which is the most likely way forward. At the time of this study, the initiative for converting the existing Farm Accountancy Data Network (FADN) into a FSDN is still ongoing and it is assumed that the Commission will adopt the initiative in the second quarter of 2022[623]. Quantitative estimations on costs for national authorities are presented in the table below.

[618] 2020 data available from the OECD. See: https://stats.oecd.org/Index.aspx?DataSetCode=ICT_HH2#

[619] See footnote 622

[620] The estimation on time spent is based on observations from the existing IPM recording system in Finland in which farmers can voluntarily record IPM measures. The time is purely for recording and not for field observations and planning, which is part of the normal IPM process and not the recording. It should also be mentioned that farmers in general already record all agronomic practices from land preparation to harvest and that the time assumed here is for transferring information from their existing system into the framework provided by the national authorities. It can be assumed that the time needed would decrease over time if recording gets more standardised and streamlined.

[621] Labour costs include wage as well as indirect costs/overheads (e.g. social contributions).

[622] The estimation is based on findings from the study Baiocco, S. et al (2019): Labour costs in agriculture: comparative study. The estimation presented here is based on the assumption that the farm manager or another permanent staff member is in charge of the administrative tasks and to a large extent based on "imaginary worker" type 1 presented in the study. It should be noted that there are large differences in labour costs between different countries in the EU also between different types of workers (e.g. seasonal, permanent, specialised). Since the estimations are recent and inflation has been low, the costs have not been adjusted for inflation.

[623] More information can be found here: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12951-Conversion-to-a-Farm-Sustainability-Data-Network-FSDN-_en

Table 12-4 Overview of quantitative estimations of costs for national authorities

Name	Type	Assumptions	Costs	Distributional considerations
Collection and assessment of annual submissions	Recurring annually	• Across the EU, statistics from approx. 80,000 farms are collected annually through the current FADN and it is expected that this number will remain stable • A recent study on the costs for FADN data collection[624] found that, on average[625], the costs (incl. data collection, data processing and validation) per collected farm data set is around 680 EUR. • No numbers are available on how much additional costs would occur by adding IPM data collection to the process, especially since it would be part of the wider expansion of FADN into a FSDN; however, it can be estimated that additional costs would not surpass 10 EUR[626] per collected farm data.	Approx. 800k EUR annually	• The sample sizes between different MS vary • The cost per collected farm data set varies widely between different MS (the EC study found that a completed FADN Farm Return cost an average of 107 EUR in Bulgaria but 2,905 EUR in Belgium)

Source: Own elaboration

Additional costs will occur for the infrastructure. However, since data collection can build on existing processes and infrastructure, the only costs that occur are for adapting the current system. As found in a recent study on the costs for FADN data collection, although extending the collection of any type of data to the Member States that do not currently collect it would incur costs, there would be marginal to the basic data collection infrastructure already in place.

Under the current FADN, statistics from approximately 80,000 farms throughout the EU are collected annually and it is expected that this sample size remains somewhat stable. This represents only a fraction (0.8 %) of the existing farms which report data annually. Between years, the turnover rate within the samples (i.e., the number of new sampled farms compared to the prior year) differs between MS between 5 % and 30 %, with just over a third of Member States have a turnover of around 10%.

Those two metrics (sample size and sample turnover) of the FADN have an impact on the usability of the collected data for policy purposes. While not further specified in the policy option, the data could be used for policy reporting (e.g., for progress towards implementation of the SUD), within the policy cycle (e.g., for feeding into future revisions of the SUD or other IPM related policy frameworks) or for enforcement of the obligation of farmers to apply IPM. For the first two use cases, it can be assumed that the sample size and turnover are sufficient.

For the third use case, however, it can be assumed that the sample size and low turnover rate are not sufficient in addition to two supplementary factors: firstly, participation in the survey voluntary and secondly, the validation of data is mostly automated[627]. The first supplementary factor would

[624] EC (2015): Cost of and good practices for FADN data collection. See: https://op.europa.eu/en/publication-detail/-/publication/02ee48a9-d479-11e5-a4b5-01aa75ed71a1

[625] Data includes UK

[626] Based on expert judgement

[627] Around 90 % of the resources are for collection of the data and only the remaining 10% for data processing and validation

be detrimental to the use of the data for enforcement. The second factor would imply that considerably higher costs could accrue for national authorities for applying additional plausibility checks to ensure proper enforcement. While the exact costs for this cannot be quantified because too many variables are unknown, it can be assumed that those costs would be considerably higher than the ones listed in the table above.

Independent from the above considerations, the recorded data could nevertheless be used for controls and enforcement as part of policy option A1.1.MO.a (see section 12.3.2.2 below). To this end, the recording of data needs to be organised in a way that allows for following and recording regional- and crop specific IPM standards. The costs for developing those standards are covered under policy option A1.2.LE.b (see section 12.3.3.2). It can be assumed that account for those standards in the recording system would create some costs for national authorities, albeit not high.

European Institutions

Since it is also foreseen to transfer data to the EC, some costs would also accrue for this stakeholder under this policy option. However, those are likely low since it is expected that the EC would receive the already analysed data by the national authorities and would not receive the raw data from the farmers directly.

Other impacts (environmental, social, macroeconomic)

Professional users

It is likely that recording their IPM practices would increase the farmers awareness of the IPM principles and in the long term the uptake of IPM; this is in fact the rationale behind the system in Denmark in which farmers have to answer questions regarding IPM even though this data is not collected by the authorities.

If the template is designed in a way that also records economic impacts (e.g. avoided use of pesticides) this could also lead indirectly to an increased uptake of IPM because farmers would more easily see the benefits of IPM and evaluate their IPM strategy[628]. During the IPM focus group it was discussed that this aspect – the recording being useful for the farmers – is crucial for the success of this policy option since without it, there is a high risk that the data quality would suffer since farmers would be unmotivated to provide good and realistic data.

National authorities

As discussed, it is unlikely that the data collected through the upcoming FSDN could be used for enforcement purposes. However, the recorded data could be used as basis for control and enforcement purposes discussed in policy option A1.1.MO.a[629].

Also, as mentioned earlier, the data could also be used for evaluation purposes, and it should be noted that to date only very little data is available on actual IPM implementation. This new data would allow countries (and EU institutions) and research to improve the IPM policy framework in the long term; this potential benefit has also been pointed out by several respondents to the national authority survey as well as during the focus group on IPM.

[628] Input from survey with national authorities as well as from the IPM focus group.

[629] See section 12.3.2.2

General public

An increase and improvement of uptake of IPM practices is expected to more sustainable use of pesticides by giving priority to other pest-control measures. A better uptake of IPM could also contribute to a use reduction. This would generate benefits to human health and the environment, through reducing exposure to pesticides and pollution. In a long term context, it would contribute to sustainable agriculture and secure food production in the EU. These benefits are not possible to quantify or monetise.

12.3.2.2 *Impacts from option A1.1.MO.a*

Direct economic impacts

This policy option builds on two other options; the creation of standards/guidance, which is crop- and region specific (see policy option A1.2.LE.b in section 12.3.3.2), by national authorities; and the recording of farmers of their practices, following those guidelines (see policy option A1.1.ME.a in section 12.3.2.1). The costs for those policy options are covered under the respective sections. The additional costs for this policy option A1.1.MO.a are discussed below.

Currently, as per results from the survey with national authorities, three countries already have a system in place to control implementation of IPM at farm level. This includes France which controls implementation of some IPM provisions; Belgium, which controls implementation of some IPM measures for a certification scheme on sustainable agriculture and other provisions as part of CAP cross-compliance checks; and Poland[630].

Professional users

As for policy option A1.1.ME.a, this policy option only concerns farmers and no other professional users. The costs for farmers for this policy option will depend on how the final framework for controls will look like.

If the controls are to be realised under the OCR, this regulation would have to be amended through a delegated act to include those controls into its scope[631]. The OCR defines frequency and fees for different controls (e.g., controls of consignments of live animals) which must be borne by the stakeholders or, respectively, provided by national authorities to calculate their own fees at the level of cost[632]. It is not possible to foresee the fees charged by national authorities, also given that they would likely vary widely per country. However, as per Article 82 of the OCR the fees would need to be calculated as a flat-rate at a flat-rate on the basis of the overall costs of official controls borne by the competent authorities (Article 82.1(a)) or on the basis of the calculation of the actual costs of each individual official control (Article 82.1(b)).

It should be noted that the OCR also foresees actions to be taken by competent authorities as well as penalties in the case of non-compliance. Those would, in case of non-compliance, pose costs for

[630] Albeit Poland authorities also mention that it is challenging to control IPM implementation.

[631] The current OCR also covers plant health aspects; however, the aspects covered do not include the control of professional users of pesticides. The aspects currently covered include a) as per Article 22(3) of the OCR the controls in the premises and, where applicable, in other locations used by professional operators authorised to issue plant passports in accordance with Article 84(1) of Regulation (EU) 2016/2031 (further specified under Commission Implementing Regulation (EU) 2019/66) and b) as per Article 93 of the OCR which designates European Union reference laboratories for pests of plants on insects and mites, nematodes, bacteria, fungi and oomycetes, viruses, viroids, and phytoplasmas (further specified under Commission Implementing Regulation (EU) 2019/530)

[632] See Article 79 of the OCR

farmers. However, those costs, which are punitive or deterrent in nature, are not counted into the assessment of costs and benefits of this policy option.

Another aspect of potential costs for farmers stemming from this policy option which are not counted as part of the analysis are costs for farmers which so far did not comply with IPM standards and would change their practices to avoid penalties.

Another potential pathway for building on an existing mechanism for this policy option is by including the controls in the performance-based penalty system of the CAP. In the current CAP (until 2023), this is the cross-compliance mechanism; in the new CAP, starting in 2023, this will be replaced by conditionality. Controls under this mechanism would not create direct costs for farmers since the costs for the controls are borne by the public authorities. However, farmers could receive penalties in the form of reduced CAP payments. Again, those penalties do not count into the cost benefit assessment of the impact assessment, as well as the costs for changing practices. It should be noted that not all sectors/farmers receive CAP payments.

However, in any case the process needed for this policy option (creation of crop- and region specific IPM standards, preparation for recording, start of recording and submission of first data) can be expected to take a considerable amount of time before being operational. Thus, while it can be expected that this policy option is effective towards reaching the objective of improving measurability and monitoring of implementation of IPM (and through this the uptake of IPM), this would be rather in the long-term and it is unlikely that it will be instrumental in contributing to the two-pesticide related Farm to Fork targets which are to be reached by 2030.

For both pathways, farmers would also face costs due to time spent during the controls. However, it can be expected that those would be fairly low – for example, a study on administrative burden from certain rural development measures[633] found that on-the-spot checks only account for 2%[634] of all administrative costs that farmers face linked to CAP direct payments (while application for those payments account for almost 80% of all administrative costs). Thus, even if on-the-spot checks would become more time intensive due to additional cheeks of IPM implementation, those costs would be minor overall.

National authorities

For national authorities, the costs also depend on the final selected mechanism of this policy option. As mentioned, the costs for controls through the OCR are recovered from fees so eventually no costs would accrue.

For the inclusion of the IPM controls, the national authorities would face some costs for additional time spent during on-the-spot checks. Quantitative estimations on costs for national authorities are presented in the table below.

[633] Study on administrative burden reduction associated with the implementation of certain Rural Development measures, 2011, https://ec.europa.eu/agriculture/external-studies/rd-simplification_en

[634] It should be noted that the study is from 2011; however, it has also been used in the impact assessment feeding into the revision of the current CAP and thus the findings of the study are still considered relevant.

Table 12-5 Overview of quantitative estimations of costs for national authorities

Name	Type	Assumptions	Costs	Distributional considerations
Additional time spent by inspectors during on-the-spot checks as part of the CAP conditionality mechanism	Recurring annually	• It is assumed that at least 1% of all farms are annually subject to on-the-spot checks[635] • An additional time of 20min is assumed per on-the-spot checks for checking records on IPM implementation • An average hourly labour cost of 37 EUR for public authority staff is assumed[636] • Potentially also new hires would be needed to absorb additional time requirements; however, those are reflected in the calculated costs	Approx. EUR 1.3 million annually	• Costs are per farm so countries with more farms (e.g., Italy, Poland or Romania) face overall higher costs • Labour costs differ between countries • Large differences in time spent between types of farms (mainly dependent on number of lots and diversity of crops)

Source: Own elaboration

Also, for both pathways, the competent authorities would face costs for training the controllers. Since it is unclear how complex the recording framework would be, it is not possible to calculate how much training would be required.

It should be noted that during stakeholder consultations, it was mentioned that incentives for good implementation of IPM may work better than penalties for lacking implementation of IPM, since the latter might only get farmers to do the bare minimum in order to pass the checks.

Other impacts (environmental, social, macroeconomic)

An increase and improvement of uptake of IPM practices would lead to environmental and health benefits. This was broadly supported by environmental NGOs and civil society organisations which answered in the targeted survey that it could lead to a reduced use and risk of chemical pesticides to a major/moderate extent (21 out of 22 responses). The extent to which this would lead to environmental or social benefits was not clearly stated, however it is assumed to have a positive impact on the environment on the assumption that a reduced use and risk of chemical pesticides would have significant positive impacts on the environment and human health as documented in the evaluation report. From the perspective of PPP users, there was somewhat agreement that use of mandatory crop-specific IPM standards could lead to a reduction in the use and risk of pesticides (27 out of 51 PPP users in the targeted survey). Similarly, from the industry perspective, producers/manufacturers of pesticides broadly supported this view (45 out of 57 respondents answering as producers/manufacturers).

[635] As per current draft of the of the "Horizontal Regulation", Art 84(3)(d)

[636] Data about labour costs in the Member States is obtained from Eurostat's Labour Cost Survey, the latest available being 2016 (see: https://ec.europa.eu/eurostat/databrowser/view/LC_NCOST_R2__custom_1281363/default/table?lang=en; cost category "'public administration and defence, compulsory social security"), and adjusted for inflation. A 25% overhead cost is then added to obtain an average Member State daily labour cost for the public administrations. This leads to an average annual cost of approx. 63k EUR.

12.3.3 Impact from policy options addressing operational objective A1.2

This section assesses the impacts from the policy options addressing the operational objective "Operationalise IPM principles for different contexts and crops".

The following policy options are assessed:

- **Least ambitions options:**
  - **A1.2.LE.a**: Current IPM principles in annex to SUD clarified and reworded (including potential new technologies which can promote the application of IPM principles)
  - **A1.2.LE.b**: Requirement for MS to establish tailored IPM guidance (region/crop specific) representing crops covering at least 90% of UAA
- **Medium ambitious options**:
  - n/a
- **Most ambitious options**:
  - Same as **A1.1.MO.a** as that policy options addresses operational objectives A1.1 and A1.2; see section 12.3.2.2 above.

Stakeholder input on operationalising IPM principles for different contexts and crops

From the perspective of national authorities, there was some consensus that there could be further simplification and operationalisation of the IPM principles (a view agreed by nine out of 27 Member States). Specifically, there was an agreement that the rewording of the IPM principles in annex to the SUD could be further refined to make them more applicable and operational to different context and geographies.

With respect to PPP users and industry, the requirement for Member States to establish tailored IPM guidance was viewed positively, with 110 out of 151 respondents to the targeted survey answering that it would have an impact to a major/moderate extent on reducing the risk and use of pesticides in line with the farm to fork targets. Despite this, this option was also seen to contribute somewhat to administrative burden (90 out of 151 respondents). For environmental NGOs and civil society organisations, the requirement for Member States to establish tailored IPM guidance was also viewed positively. In total, 21 out of 22 respondents the targeted survey answered that it could have an impact on a reduction of risk and use to a major/ moderate extent.

12.3.3.1 *Impacts from option A1.2.LE.a*

Direct economic impacts

It is not possible to estimate direct economic impacts from this policy option since the exact revision of the IPM principles is not known to date. It can be expected that the EC would face costs for preparing the revisions (e.g. external studies and/or internal resources) but those would be relatively low.

For farmers and national authorities, it is not expected that this policy option would create additional costs since no substantial change to the current practices are foreseen.

Other impacts (environmental, social, macroeconomic)

As shown in the evaluation report, it can be expected that IPM implementation is at least partly unclear and/or lacking because enforcement and controls are often not applied since the IPM principles are general and difficult to assess in controls. Thus, a clarification of the IPM principles could lead to better uptake of IPM, and consequently to environmental and health benefits. However, there are limits to this since the principles would still have to be fairly general in order to be applicable to all plants and regional contexts and further operationalisation is needed (see next section).

12.3.3.2 *Impacts from option A1.2.LE.b*

Direct economic impacts

The table below shows the crop specific IPM guidelines that are already in place in the EU Member States.

Table 12-6 Development of IPM guidelines in the Member States

Member State	Number of IPM guidelines	Crops for which guidelines have been developed	% of utilised agricultural area for which IPM guidelines have been developed
Austria	2	Cereals, vineyards	no information
Belgium	3	No further detailed information	no information
Bulgaria	47	Guidelines approved in 2008, and have not been updated since; updating of the Guidelines was an action under Measure 6 of the NAP, but it was re-scheduled for the end of 2022	90%
Croatia	4	Field crops, vineyards	6.8%
Cyprus	1	Vineyards	no information
Czechia	31	Range of field crops, permanent crops and vegetables	95%
Denmark	60-70	Guidelines covering all major crops	no information
Estonia	26	No further details available	49.7%
Finland		No information, states that IPM Guidelines are available, and these were developed by private stakeholder, but no specific information on number and crops	no information
France	5	Guidelines for arable crops, viticulture, vegetable growing, fruit growing and tropical crops	no information
Germany	17	Fruit and vegetables; golf courses; sugar beet; home gardening; medicinal and aromatic plants/herbs; urban greening; gardening, landscaping and sportsground construction; maize; railway tracks; nurseries; woods/forests; storage protection; potatoes; arable farming; vineyards; hops; ornamental plants	no information
Greece	7	Vineyards, tobacco, cherry, rice, kiwi, olives and cotton	24%
Hungary	40	No information	90%
Ireland	3	1 general Guidance document, and 2 crop-specific Guidance documents; however, both crop-specific ones are focused on crop management in general rather than specifically on IPM	no information
Italy	Developed at regional level	E.g., 78 crop-specific IPM protocols (55 for arable crops, 16 for fruit trees and 7 for medicinal plants) in Campania, and 98 in Tuscany	95%
Latvia	25	No further details available	Almost 100%
Lithuania	20	Winter wheat, spring wheat, spring barley, peas, winter oilseed rapes, winter triticale, oats, potatoes, carrots, apples, beans, winter rye, spring oilseed rape, corn, buckwheat, beet, cabbage, onions, black currants and strawberries	no information
Luxembourg	0	No information	no information
Malta		Reported that guidelines are available but no further details on the number and/or crops covered	
Netherlands	60	Mainly crop/pest control measures listed, without giving emphasis on non-chemical alternatives; in	no information

Member State	Number of IPM guidelines	Crops for which guidelines have been developed	% of utilised agricultural area for which IPM guidelines have been developed
		addition, crop-specific Guidelines were available, which are developed by other stakeholders	
Poland	68	Covering a wide range of crops, forestry, mushroom production and gardening for non-professional users	98%
Portugal	72	1 general and 71 crop-specific guidelines	no information
Romania	1	General IPM guidelines, crop specific guidelines under development	no information
Slovakia	0		no information
Slovenia	4	No further details on crops/groups of crops covered	no information
Spain	26	Guidelines including forestry and agricultural crops	80%
Sweden	10	No information	36%

Source: EU Commission data based on 2017 web survey among Member States, complemented with audits and fact-finding missions (status as per 2021)

As can be seen, there are large differences between the Member States. However, most Member States generally have specific guidelines in place, some of which already meeting the target of 90% of the utilised agricultural area. However, it should be noted that there is no one definition of what an IPM guideline is, and that there are major differences of how those can be and have been approached[637]. Thus, even if guidelines exist, there are large differences between Member States in what they define in detail.

The above should be seen as baseline to this policy option, and defines the costs for the different stakeholders together with a crucial second factor which is the specific result this policy option aims to achieve. There are two main options in this regard.

National authorities and European institutions

A first possibility is that the policy option aims at improving IPM practice by providing specific guidance to farmers, accounting for the fact that the overall IPM principles are general and hard to operationalise for farmers. To this end, crop-specific guidance could help farmers taking sensible decisions in their day-to-day work and improving the implementation of IPM. To improve effectiveness, it would likely be beneficial if the European Institutions could define minimum quality standards for crop-specific guidelines. Those would likely require at least parts of the existing guidelines to be revised. However, it can be expected that a large share of the existing catalogue of crop-specific guidelines could be maintained. In this case, the Member States which do not yet have guidelines in place would face costs for developing them.

The second possibility goes further than this by providing considerably more specificity of what a crop-specific guideline is. This would be required in order for this policy option to be the basis of policy option A1.1.MO.a (see section 12.3.2.2 above), i.e., by highly operationalising the guidelines to an extent at which they can be used a) as a concrete decision-making tool by farmers (e.g. in the form of a decision-tress) and b) as a basis for controls and enforcement.

This second possibility would likely cause higher costs for the European Institutions and the Member State authorities. For the European Commission, costs would likely occur for developing detailed provisions for the Member States to guide the development of guidelines. For Member States, it is likely that they would have to revise the majority of existing guidelines.

[637] As per findings from the focus group on IPM measures.

Professional users

The costs for the farmers cannot be defined since, even if they would have to adapt practices following specific guidelines, this will vary widely at rotation level per plot/field in addition to the crop level and with considerable differences across crops, regions, production types and even farmers within a region. In addition, since only very scarce data on the actual implementation of IPM at farm level exists, no baseline can be created.

In addition to potential costs, however, it can also be expected that this policy option would entail benefits for farmers due to the existence of guidance which to some extent can replace own research and potentially bad practices.

Other impacts (environmental, social, macroeconomic)

An increase and improvement of uptake of IPM practices is expected to more sustainable use of pesticides by giving priority to other pest-control measures. A better uptake of IPM could also contribute to a use reduction. This would generate benefits to human health and the environment, through reducing exposure to pesticides and pollution. Over the long term, it would contribute to sustainable agriculture and secure food production in the EU. These benefits are not possible to quantify or monetise.

12.3.4 Impact from policy options addressing operational objective A1.3

This section assesses the impacts from the policy options addressing the operational objective "Improve implementation of obligation to create incentives / compensation for farmers for using IPM".

The following policy option is assessed:

- **Least ambitions options:**
  - **A1.3.LE.a**: Further emphasise the current SUD compulsory requirement for MS to introduce incentives for the use of non-chemical pest control alternatives and methods as well as for any IPM measure that may lead to economic losses for farmers (e.g. crop rotation)
- **Medium ambitious options**:
  - n/a
- **Most ambitious options**:
  - n/a

Stakeholder views on improving the implementation of an obligation to create incentives/compensation for farmers for using IPM

From the perspective of PPP users and respective industries, two of the most salient answers to question of significant compliance cost or burden caused (or in part) by the SUD, was that there is a lack of effective alternatives to chemical PPPs (37 out of 42 respondents to the targeted survey) and higher costs of alternatives to chemical PPPs (34 out of 42 respondents). Interestingly, when asked of the factors which contribute to the uptake of IPM practices, the option of "incentives for farmers and other professional users to adopt IPM principles" (86 out of 105 respondents) comparatively gathered less support compared to the options of "availability of adapted IPM solutions" (99 out of 105 respondents) and "high level of expertise of farmers and other professional users on IPM" (95 out of 105 respondents). Thus, this suggests that support to farmers using IPM is best seen through the availability of solutions rather than compensation.

Interestingly, this is a view that was shared by Member State authorities, where higher costs for alternatives to chemical pesticides and a lack of alternatives ranked highest in the targeted survey as a factor which influences the current uptake of IPM practices in their Member State/Country (17 out of 18 respondents, or a view shared by 7 Member States[638]) compared to a lack of incentives. Similarly, this is a view broadly supported by environmental NGOs and civil society organisations, where the lack of expertise and capabilities of farmers was seen to be a greater obstacle to the uptake of IPM compared to introducing incentives for farmers.

12.3.4.1 *Impacts from option A1.3.LE.a*

Direct economic impacts

As per Article 14(5) of the current SUD "Member States shall establish appropriate incentives to encourage professional users to implement crop or sector-specific guidelines for IPM on a voluntary basis"[639]. In the Member State survey, the competent authorities were asked if their respective country established financial support schemes in the last 10 years for farmers that apply IPM, to which nine replied "yes", eight "no, and eleven "don't know". Those that replied "yes" were asked to provide more detail; two of those[640] specified, that within the CAP framework extra subsidies are included for specific practices (e.g. full mechanical weed control).

As can be seen, this provision is already part of the current SUD, but implementation seems to lack in several countries. Thus, costs stemming from this policy option for the Member States should not be considered when comparing policy options since it only aims at further enforcing the current legal provisions. It can be expected that those countries that did not yet put such mechanisms in place would face one-off costs for transposing the provision. Also, Member States face the annual costs of payments to the farmers, who are the beneficiaries.

The policy option does not further specify the delivery mechanism of the incentives to be introduced since this is left open to Member States. Thus, costs from the implementation of this policy option will vary from country to country. It can be considered, however, that the CAP (and more specifically the "conditionality") could be an appropriate delivery mechanism. In this case, the costs faced by the Member States would be covered through the CAP funding.

Given the framework nature of the SUD (and given the variation in agriculture across the EU), considerable flexibility is granted to the national authorities on how to implement provisions in detail. This also includes the question of which practices could be incentivised (with crop rotation being one example provided in the policy option). In this context it should be noted that through Article 14(4)[641] of the current SUD, IPM is obligatory for all professional users. Thus, it should be considered to change the wording of Article 14(5) and this policy option from "incentives" to "compensation".

Following the framework nature of the SUD, it can be considered to leave it to the Member States which specific practices they want to compensate. If the compensation is delivered through the CAP, it could also be considered to link this policy option to policy option A1.1.MO.a (see section 12.3.2.2) on using crop-specific IPM standards as a basis for controls and enforcement.

[638] Croatia, Ireland, Latvia, Luxembourg, Poland, Slovenia, Spain

[639] See: https://eur-lex.europa.eu/eli/dir/2009/128/2009-11-25

[640] France and Belgium

[641] "Member States shall describe in their National Action Plans how they ensure that the general principles of IPM as set out in Annex III are implemented by all professional users by 1 January 2014."

Other impacts (environmental, social, macroeconomic)

It can be expected that a well-working compensation mechanism would lead to an increased uptake of IPM practices since it would directly counter potential economic risks that farmers take when implementing IPM practices instead of other, less risky options e.g. the use of chemical pesticides. This increased uptake of IPM practices would likely lead to environmental and health benefits.

12.3.5 Impact from policy options addressing operational objective A1.4

This section assesses the impacts from the policy options addressing the operational objective "Ensure that advisory services can provide robust advice on IPM".

The following policy options are assessed:

- **Least ambitions options:**
  - **A1.4.LE.a**: Introduce a legal requirement for more detailed training and holding of a relevant certificate for all advisors
- **Medium ambitious options**:
  - **A1.4.ME.a**: A1.4.LE.a + Strengthened role and rules for independent advisory service to professional pesticide users (decoupled from economic interest of selling pesticides and PAE), including link to possible prescription system/obligatory advice
- **Most ambitious options**:
  - n/a

Stakeholder views on ensuring that advisory services can provide robust advice on IPM

Across all the stakeholder consultations, a recurring view that was broadly supported across all stakeholder groups was the need for enhanced advisory services. Indeed, in both the targeted surveys to PPP users and industry and environmental NGOs and civil society organisations, the view option of "high level of expertise of advisory services on IPM" was seen to be an important factor in the uptake of IPM. Despite this, there was also the acknowledgement that a requirement of more detailed training for advisors, especially on IPM would be overly burdensome or costly to implement (a view shared by 84 out of 151 users/ industry representatives). From the Member State authority perspective however, the lack of technical services to train and advise farmers and other professional users on IPM practices was not seen to comparatively be an important factor in the uptake of IPM, as found in the targeted survey to Member State authorities.

There was agreement from stakeholders on what the wider impacts from the policy option would be and opinions range from very positive expectations to very negative expectations. The main arguments are listed below:

- **Positive**
  - Some stakeholders expect that the independence would result in a decrease of the use of pesticides leading to environmental and social benefits (incl. through elimination of non-essential treatments, elimination of unnecessary combined treatments of different active substances, etc.)
- **Negative**
  - Several stakeholders are concerned that the expected higher cost from advice would deter farmers from seeking advice which would likely lead to implementation of worse practices. This would be mitigated if advisory services were to be mandatory.
  - There is a concern that farmers would seek advice nevertheless from sellers of pesticide since they are qualified, even though they would not be officially advisors. Over time, if this practice continues, the quality of advice would decrease since sellers are in general subject to less stringent training obligations than advisors

- There were also concerns linked to the point that it will be very difficult for national authorities to define and ensure "independence".
- Another point frequently pointed out is an expected shortage of suitably qualified advisors, with sufficient IPM knowledge and experience (addressed in least ambitious option on training of advisors).
- An additional point, and related to the governance of such a system, is that farmers should know the difference between advice from an independent advisor and an advisor with financial interest and can judge the advice against that background. In this context it has been mentioned that it would be better to train pesticide users better instead of building an additional administrative system

12.3.5.1 *Impacts from option A1.4.LE.a*

Direct economic impacts

Advisors in the context of the SUD are defined in Article 3(3) as "any person who has acquired adequate knowledge and advises on pest management and the safe use of pesticides, in the context of a professional capacity or commercial service, including private self-employed and public advisory services, commercial agents, food producers and retailers where applicable".

It is important to note that those advisors are not necessarily the same as the advisors of the Farm Advisory System (FAS) mechanism under the CAP. While the FAS as per current[642] and future[643] horizontal regulation also specifically covers the implementation of the SUD, the scope of advice between the two groups of advisors is often perceived different, with FAS advisors as dedicated to CAP advisory services.

Article 5(1) of the SUD then further specifies that advisors should have "access to appropriate training by bodies designated by the competent authorities. This shall consist of both initial and additional training to acquire and update knowledge as appropriate". Annex 1 of the SUD provides a list of subjects that the training should cover as a minimum; regarding IPM, the Annex specifies that the training should include (among others) "Notions on IPM strategies and techniques, integrated crop management strategies and techniques, organic farming principles, biological pest control methods, information on the general principles and crop or sector-specific guidelines for IPM".

The list with training subjects is the same for users, distributors, and advisors; however, Article 5(1) lines out that the training for the different actors "should be designed […] taking account of their different roles and responsibilities".

Thus, in short, in terms of details of the training, Annex I provides the topics. In terms of training received compared to other stakeholders (such as professional users), the only reference made is that the training should be designed taking account of their role and responsibility. However, this implies that to some extent, "more detailed training" than other stakeholders is already part of the current legislative framework.

This is also the interpretation of several Member States[644]. The survey highlighted that advisors already receive a more detailed training than other stakeholder groups. Four of those Member

[642] See Article 12(1)(e) in https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32013R1306

[643] See Article 13(4)(b) in https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A392%3AFIN

[644] Emphasised in 9 out of 20 replies to an open question.

States also highlighted that currently, the advisors are already obligated to complete a relevant university degree, or that they already belong to the most experienced IPM experts in the country – which raises the question of "who would train them"?[645]

The above status quo reflects the framework nature of the SUD which, while it sets out general conditions on who qualifies as an advisor, it nevertheless provides for a lot of flexibility on the details of the relevant provisions which leads to a complex portfolio of different national and even national and regional approaches as the baseline.

The policy option also requires that all advisors should receive a relevant certificate. However, this provision is already part of the baseline since Article 5(2) of the current SUD establishes that advisors need to hold certificates that "as a minimum, provide evidence of sufficient knowledge" on the topics in Annex 1 and the evaluation found that this provision has been implemented throughout almost all countries. [646]

Below, the costs of this policy option for the different stakeholder groups are discussed against this baseline.

National authorities

In terms of cost for national authorities, there are costs for developing the more detailed training, rolling it out, and conducting it.

For developing the more detailed training, given that in several Member States, the advisors already receive thorough training, and given the need for crop- and region-specific advice, it is unlikely that at European level new topics and detail could be added with relevance and added value for all of Europe. One possibility to enhance the training with relevance for all of Europe includes linking the additional training more specifically to the guidelines that are discussed to be developed under policy option A1.2.LE.b (see section 12.3.3.2). The costs for doing so are also discussed in that section.

For rolling out the training, it is assumed that only little cost would occur since almost all countries can build on a well-established training system into which the new training subjects can be integrated.[647]

In terms of costs for conducting the trainings, results from the member state survey have shown that in most cases, the costs are fully recovered through fees from the trained stakeholders[648] as can be seen from the figure below.

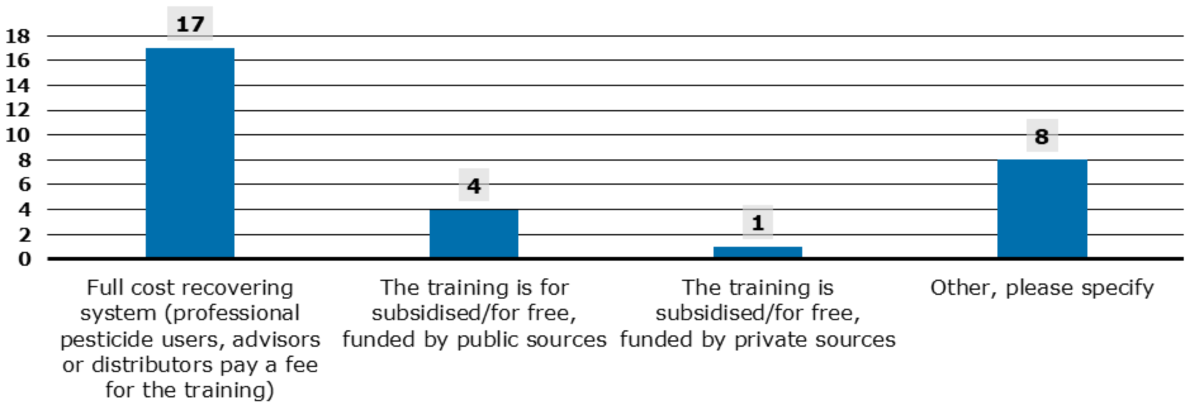
[645] Quote from the survey.

[646] However, this is not the case in all Member States since the 2019 audit in Romania found that no system for training and certifying distributors, advisors and professional users had been established and that the necessary legislation had only been in place since March 2019. A subsequent action plan by the Member State authorities from January 2021 confirms that trainings will shortly be started and that it is assumed that by end 2023 all stakeholders will have received initial training.

[647] The evaluation of the SUD found that for establishing the training system of the current SUD, despite it establishing a range of topics to be covered by covered (see Annex I f the SUD), only comparably little cost have occurred (in total five replies provided an estimation, all of them around 1 to 2 FTE for one year, for setting up the scheme for the central governments). Given that through this policy option only of topic (IPM) would be further elaborated on, it can be assumed that the costs will be negligible.

[648] In the "other" category, five replies pointed out that within one Member State there are different models that co-exist. Two of those replies also mentioned that the systems are decided on and differ between the regions in the respective MS. One reply pointed out that there are differences between stakeholder groups, i.e., that distributors have to pay for training while it is free for professional users.

Figure 12.1 Survey with national authorities: *Please provide information on how the training and certification system is financed*



Source: Own elaboration based on survey with national authorities

Given that in the majority of cases, the costs are recovered through fees from the advisors, the costs for conducting the trainings are discussed below in more detail. In short, no numbers on the total numbers of advisors are available, but it is estimated that an additional 7 EUR per advisor would accrue for this policy option for countries in which training is funded by public sources.[649]

Advisors

Through the survey with national authorities, respondents provided estimates on average training costs for advisors[650]. The table below summarises the detailed replies.

Table 12-7 Estimates of training and certification costs for advisors in cases where the courses are fully financed through fees

Costs	Member State
40 EUR	CZ
40 EUR	RO
40-50 EUR	HR
75 EUR	PL
Basic training: 120 EUR; advanced training: 70 EUR	EE
165 EUR	SI
235 EUR	LV
250 EUR	IS
300 EUR	ES
Between 0 - 360 EUR (depending on training centre)	BE (Wallonia)
Basic course: 400 EUR; follow-up course: free	BE (Flanders)
420 EUR, renewal courses every 5 years: 210 EUR	FR
450 EUR	NL
Basic course: 500 EUR; follow-up course: 200 EUR	SE
Depends on the provider of the training	FI

Source: Own elaboration based on survey with national authorities

[649] Since fees in Table 12-7 are reported to fully cover the costs for training it is assumed that they are representative for the costs that national authorities would face.

[650] Through the survey, estimates were also collected on costs for trainings for professional users and distributors. The results showed that in most MS there are differences between the training costs for different stakeholder groups and typically, the costs for professional users are lower than for the other stakeholder groups. Only in three cases the professional users face higher cost than one or both of the other stakeholder groups.

As can be seen, there are large differences between countries and complexity is added by different prices for basic and follow-up courses. However, based on the numbers, it can be assumed that the average for one training at European level is at around 200 EUR.

Based on the information above, estimated costs of the policy option are presented in the table below.

Table 12-8 Overview of quantitative estimations of costs for advisors

Name	Type	Assumptions	Costs	Distributional considerations
Additional costs for advisors for more detailed training	Recurring annually	• Current average cost per training is 200 EUR (see above) • The policy option does not specify what the more detailed training would entail, and it thus cannot be calculated how much additional time would be needed. However, based on expert opinion, it is assumed that the training could be extended by 20% (leading to 20% higher costs per training, i.e. 240 EUR in total). However, depending on the requirements of the new training, e.g. if it is stronger focused on in-depth training for IPM this could also be higher. Thus, the cost should be understood as minimum • The SUD does not prescribe specific or minimum intervals for renewals of trainings and no recent data exists on renewal intervals. However, through a 2013 survey from the EC to Member States[651] it was found that the duration of validity ranges from a minimum of 2 years to a maximum of 10 years; it is assumed that this has not changed significantly and that on average the certificate must be renewed every 6 years • No concrete figures exist on total numbers of advisors in the countries and thus only the additional cost per advisor can be calculated and not the overall costs across all countries	At least 7 EUR annually per advisor[652]	• There are considerable differences between countries for costs for training (see Table 12-7 above)

Source: Own elaboration

Professional users

Several replies to the survey with national authorities pointed out that a more detailed training obligation for advisors would be possible and would potentially reap benefits, including to reduced costs for famers due to reduced use of pesticides.

[651] See: https://web.archive.org/web/20200513184638/https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_sup_overview-sud-training-certification-systems-2013.pdf

[652] Based on assumptions presented in the column "assumptions", i.e. a 20% extension of current training costs

Other impacts (environmental, social, macroeconomic)

IPM techniques require an understanding of a wide range of possible solutions that are strongly dependent on the precise context of a farm and a field. Thorough knowledge of currently available options is necessary for finding the right approach. A lack of such knowledge is described in academic literature[653] and EU reports[654] as an important barrier to the uptake of IPM. Advisory services can help to close this knowledge gap and provide the information to farmers.

Thus, strengthening the advisory services could contribute significantly to the uptake of IPM, which would lead to environmental and social benefits. There are likely limits to the benefits that additional training of advisors could generate in some countries as shown above; at the same time, there seems to be room to improve the training of advisors in other countries.

However, it should be noted that the evaluation found that one additional weakness of the current advisor system is a lack of financial capacities as well as staff which should also be addressed by Member States[655].

12.3.5.2 *Impacts from option A1.4.ME.a*

Direct economic impacts

As mentioned earlier, advisors in the context of the SUD are defined in Article 3(3) as "any person who has acquired adequate knowledge and advises on pest management and the safe use of pesticides, in the context of a professional capacity or commercial service, including private self-employed and public advisory services, commercial agents, food producers and retailers where applicable". Those advisors need to receive specific training (including on IPM) and a certificate on that training (see section 12.3.5.1 for more detail).[656]

Thus, in short, advisors can come from public bodies, but also from the private sector; in the private sector, advisors include staff from commercial agents, pesticides industry, retailers and independents, most of which have at least partly a commercial interest in selling pesticides.

No detailed picture is available about the advisor systems in the countries, including on total numbers of advisors and on the share of public and private advisors.

This policy option is likely to entail additional costs for a range of stakeholders and require restructuring of the farm advisory services market in most Member States. As of 1 January 2021, such a separation between economic interests of advisors from sales of is in place in France and it is mandatory for commercial farms to receive so called "strategic advice" from an independent advisor. Although too early to evaluate the effects ex-post, our study draws on the estimated impacts from the recent changes in France.

The sections below discuss potential costs and benefits for stakeholder groups. Since the option would be highly disruptive to the current system and the baseline is not known, the costs are mainly

[653] Lamichhane et al. (2018) A call for stakeholders to boost IPM in Europe: a vision based on the three-year European research area network project, International Journal of Pest Management, 64:4, 352-358, DOI: 10.1080/09670874.2018.1435924

[654] DG SANTE 2017-629. Overview Report on the Implementation of Member States' Measures to Achieve the Sustainable Use of Pesticides under Directive 2009/128/EC

[655] This has been confirmed through a range of interviews and is also described in DG SANTE's 2017 overview report. See: https://ec.europa.eu/food/system/files/2017-10/pesticides_sup_report-overview_en.pdf

[656] It should be pointed out again that those advisors are not necessarily the same as the advisors of the Farm Advisory System (FAS) mechanism under the CAP. While the FAS as per current and future horizontal regulation also specifically covers the implementation of the SUD, the scope of advice between the two groups of advisors is different.

discussed qualitatively. It should be noted that through the survey with country officials two countries (Sweden and Finland) have confirmed that their advisory system already predominantly consists of independent advisors. The discussion below is mainly on the other countries with larger shares of non-independent advisors and it should be kept in mind that the costs for countries like Sweden and Finland would likely be considerably lower.

National authorities

It can be expected that national authorities would face costs to ensure that sufficient and sufficiently qualified advisors would be available in their country, to control/inspect their advisory services and uptake of services by farmers. This will likely differ considerably between Member States. In France, the main costs stemming from the recent change is the cost of control, and inspection of certificates of advisory services and the certificate for professional use of PPP (renewal of certificate for professional users will be conditional to having received strategic advice). In France, the total cost for public administration is estimated to approximately 530 000 Euro annually for these controls.

Professional users

The majority of stakeholders agree that this policy option would lead to a modest to significant increase of costs for farmers that seek advice from advisors, partly because there could be fewer advisors (leading to an increase in their prices). Plus, in many Member States, advice is provided by PPP distributors, with the cost of advice integrated in the price of the pesticide. This change could potentially lead to an increase in margins on pesticide prices, due to advisory services not being included, however it remains uncertain whether farmers would benefit from this.

It can be expected that direct cost of advisory services would increase for professional users, the estimation from France arrives at a total cost of 540 Euro per year for large farms and 180 Euro per year for smaller farms for the obligatory "strategic advice". For more specific advice on treatment, it estimates 1 500 Euro annually for large farms, and 300 Euro annually for smaller farms.

It is also assumed that the change would lead to a decrease of pesticide use overall (due to increased quality of the service and decoupling from commercial interest) which may balance the increased costs. In the French impact assessment it was estimated that farms could save up to 25% of their pesticide input costs, which would offset the additional costs for buying mandatory advice (ot was estimated that French farmers spend app. 10.000 Euro per year on PPP on average, thus generating a net benefit of 2.500 Euro per year once strategic advice and specific advice has been fully implemented)[657].

The costs from the change of the system could be partly balanced by higher subsidies or support to independent advisory structures.

Advisors

Independent advisory services (where these exist) would mainly benefit from this option, since they could expect an increased market share. Advisory services currently connected to economic interests of pesticide industry and distributors would need to be decoupled from the financial interests, this could potentially lead to costs. In France where this change is in place since 2021, it has mainly led to a creation of parallel structures according to stakeholder interviews, however it

[657] It should however be noted that a key finding in the evaluation of SUD was that expected gains to farmers has thus for not materialised, e.g. there are no signs of reduced costs for pesticides benefiting professional users.

remains to be seen how the change will affect the actual advice provided in practice. Over a longer term, this option could serve to strengthen the service sector of advisors.

This could be slightly balanced by the effect expected by some stakeholders that farmers would in general seek less advice due to likely higher prices. At the same time, this effect could be balanced if this policy option is linked to a prescription system and/or obligatory advice, in which case the farmers would be obliged to seek independent advisory services.

Some stakeholders also expect that this policy option would lead to increased income opportunities for certified independent advisors who may be paid additionally for providing the advising service instead of based on percentages of PPP sales. In this regard, it was also mentioned that advisors could have a steadier income as they will probably change to an hourly payment system.

On side of the distributors and pesticide industry, it is less clear what the impacts would be but potentially they would be fairly limited. This is because for those advisors connected to industry, typically advice is not the main income but rather an addition to their core activity (e.g. selling pesticides or PAE). If there is a significant decrease in pesticide sales or if the margin on pesticides is reduced, their income would likely be more affected. This could to some extent be offset by new technologies and biocontrol, where the market share would be expected to increase.

Other impacts (environmental, social, macroeconomic)

If the option is successful in producing higher quality advisory services to professional users of pesticides, this should lead to an increased uptake of IPM and alternative methods to pest control, which could lead to a reduction in use and in risk of pesticides. The benefits would apply to the users and bystanders, through less exposure and to society in general. It would likely be a benefit to the environment, due to less pollution and contamination of pesticides in soil and water. See also discussion on environmental and social impacts in Appendix 1.

12.3.6 Comparison of options addressing the limited operationalisation of IPM principles (specific objective A1)

Table 12-9 Comparison of options addressing the limited operationalisation of IPM principles (specific objective A1)

	A1.1.ME.a	A1.1.MO.a	A1.2.LE.a	A1.2.LE.b	A1.3.LE.a	A1.4.LE.a	A1.4.ME.a
Impacts							
Professional users	**Buying equipment: --** *Approx. EUR 278 million (per farmer on average 27 EUR)* **Time for recording IPM practices: --** *Approx. EUR 742 million annually (per farmer on average 72 EUR)* **Potential for saving on expenses for pesticides: (++)**	**Fees for controls: /[658] to --[659]** *Depends on the mechanism chosen for the controls* **Time spent during controls: -** **Potential for saving on expenses for pesticides: (++)**	**Potential for saving on expenses for pesticides:** (++)	**Potential costs for adapting practices: (/ to --)** *Will vary widely at rotation level per plot/field in addition to the crop level and with considerable differences across crops, regions, production types* **Potential for saving on time spent for research, costs for advisors, and expenses for pesticides: (++)**	**Compensation for use of non-chemical pest control alternatives and methods as well as for any IPM measure that may lead to economic losses for farmers: ++**	**Potential for saving on expenses for pesticides:** (++) **Potential costs from increased fees from advisors that hand pass on increased training costs:** (-)	**Increase of costs for advisory services: - to --** **Potential for saving on expenses for pesticides: (+)**
National authorities	**Collection and assessment of annual submissions:** --	**Costs for controls: /[660] to --[661]** *Approx. EUR 1.3*	/	**Revision of existing and creation of new**	**Funding for compensations: --**	**Rolling out the training:** - **Conducting training: -**	**Cost for ensuring that sufficient and sufficiently**

[658] CAP
[659] OCR
[660] OCR
[661] CAP

	A1.1.ME.a	A1.1.MO.a	A1.2.LE.a	A1.2.LE.b	A1.3.LE.a	A1.4.LE.a	A1.4.ME.a
	Approx. 800k EUR annually **Cost for adapting infrastructure: -**	*million annually if included in CAP conditionality* **Training of controllers: --**		**guidelines: - to ---** *Costs depend to a large extent on how prescriptive the minimum criteria for the guidelines are. If they are very prescriptive, likely a large part of existing guidelines would have to be changes.*	*Compensation could also come from CAP resources*	*At least 7 EUR per advisor annually for those countries that do not recover costs for trainings from the participants*	**qualified advisors are available: ---**
European Institutions	**Assessment of data submitted by NA[662]: -**	/	**Resources for revision of IPM principles: -**	**Costs for defining minimum criteria for the guidelines: -**	/	/	/
Other stakeholders	/	/	/	**Consultancies and research institutes: ++** *Would receive funding and resources for development and revision of guidelines*	/	**Advisors: -** *At least 7 EUR per advisor annually for those countries that do recover costs for trainings from the participants*	**Advisors: -- to ++**
General society (Environmental. social,	**Better policies on pesticide**	**Environmental and social benefits: (++)**	**Environmental and social benefits: (++)**	**Environmental and social benefits: (++)**	**Environmental and social benefits: (++)**	**Environmental and social benefits: (++)**	**Environmental and social benefits: (++)**

[662] National authorities

	A1.1.ME.a	A1.1.MO.a	A1.2.LE.a	A1.2.LE.b	A1.3.LE.a	A1.4.LE.a	A1.4.ME.a
macroeconomic impacts)	**use and IPM: ++** **Environmental and social benefits: (++)** *From increased uptake of IPM and decreased use and risk of us from pesticides*	*From increased uptake of IPM and decreased use and risk of us from pesticides*	*From increased uptake of IPM and decreased use and risk of us from pesticides*	*From increased uptake of IPM and decreased use and risk of us from pesticides* *(Potential conflicts with farmers)*	*From increased uptake of IPM and decreased use and risk of us from pesticides*	*From increased uptake of IPM and decreased use and risk of us from pesticides*	*From increased uptake of IPM and decreased use and risk of us from pesticides*
Other criteria							
Effectiveness	**- to ++** *Has the potential to be highly effective as a basis for better data and measurability of the implementation of IPM; however, only in combination with A1.1.MO.a suitable for enforcement*	**+ to +++** *Has the potential to be highly effective in improving monitoring. However, this depends to a large extent on the suitability of the implementation of policy options A1.1.ME.a and A1.2.LE.b in terms of the quality of data they produce and acceptance of farmers*	**+**	**++ to +++** *Effectiveness depends on level of prescription by the EC. Even if little prescriptive, however, the option can be effective by increasing the number of guidelines in countries with only little coverage.* *Effectiveness of the policy option is increased if it can also feed into policy options D3.2.LE.a and A1.4.LE.a and work as foundation for policy option A1.1.MO.a (the latter would*	**+++** *It can be expected that a well-working compensation mechanism would lead to an increased uptake of IPM practices since it would directly counter potential economic risks that farmers take when implementing IPM practices instead of other, less risky options (like e.g. the use of chemical pesticides).* ***(Effectiveness in the long-term: -*** *There are risks that the policy option is not*	**+ to ++** *Effectiveness depends on the country. In some countries there seems to be potential for adding more detail to training for advisors in a meaningful way. In other countries, advisors already receive exhaustive training, and it is unlikely that more detail can be added.* *However, in both cases, the training could be linked to the guidelines that could be created under policy option A1.2.LE.b*	*(Uncertainty, see discussion in section 12.3.5.2)*

	A1.1.ME.a	A1.1.MO.a	A1.2.LE.a	A1.2.LE.b	A1.3.LE.a	A1.4.LE.a	A1.4.ME.a
				require a higher level of prescription by the EC)	*sustainable in the long term since there is a risk that compensation for practices will not lead to behavioural change of the farmers but rather to income optimisation; in the latter case, if funding is stopped, it is likely that practice would change again)*		
Coherence	*No coherence issues*	*No coherence issues*	*No coherence issues*	*No coherence issues*	*No coherence issues*	*No coherence issues*	*No coherence issues*
Efficiency	**- to ++** *There are some costs associated, especially for farmers; however, recording can lead to economic benefits for farmers to balance this. Proportionality and efficiency depend on if A1.1.MO.a is implemented. If not, it should be considered to only have the*	**+ to ++** *Depending on quality of results (benefits) this policy option is likely efficient*	**+** *Since effectiveness of the option but also costs are relatively low, it can be considered efficient* *Standing alone, the policy option would not be proportionate to address the issues in operationalisation of the IPM principles but as*	**+ to ++** *Depends largely on the factors descried above*	**- to +** *Efficiency and proportionality are difficult to judge.* *Compensation would be paid for a legal obligation (implementing IPM) and thus for compliance costs. It is unclear if in this case the option is proportionate, especially since farmers are in*	**++** *Efficiency of this option is considered to be fairly high since those countries with higher effectiveness would also be the ones with higher costs (and vice versa).*	*(Uncertainty, see discussion in section 12.3.5.2)*

	A1.1.ME.a	A1.1.MO.a	A1.2.LE.a	A1.2.LE.b	A1.3.LE.a	A1.4.LE.a	A1.4.ME.a
	farmers collect the data that will also submit it. *The overall benefits for society are potentially high from better IPM data (leading to better policies)*		*part of the overall policy options in can play a role*		*the long terms expected to have economic benefits from it (reduced pesticide use)*		
Proportionality	++ *Even though this would be a new administrative burden and a large new data collection exercise, it can be considered proportional since the potential positive effects (see effectiveness) could be a strong basis for the SUD to better achieve its objectives.*	++ *Same as for A1.1.ME. a*	+++ *Effort needed for this is highly proportionate given the potential benefits from achieving an increased uptake of IPM*	+++ *Effort needed for this is highly proportionate given the potential benefits from achieving an increased uptake of IPM*	*See efficiency discussion*	+++ *Effort needed for this is highly proportionate given the potential benefits from achieving an increased uptake of IPM*	*(Uncertainty, see discussion in section 12.3.5.2)*
Subsidiarity	No issues	No issues	No issues	No issues	No issues	No issues	No issues

/: no impact
Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)
(): brackets if costs, benefits etc. are only potentially
If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +
The green coloured cells pertain to the preferred option of the Commission
The blue coloured cells pertain to the option that was assessed positively from the Assessment

12.4 Impact from policy options addressing the testing of pesticides equipment (specific objective A2)

12.4.1 Overview

The table overleaf below summarises the options for achieving this objective.

Table 12-10 Policy options for addressing the specific objective

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitious option
A2: Improve controls and apply harmonised standards	• **A2.1**: Harmonise testing of pesticides application equipment across the EU	• **A2.1.LE.a:** Further promote guidelines, harmonised methodology where CEN standards exist and stimulate knowledge sharing among Member States • **A2.1.LE.b:** Introduce a requirement for PAE to be registered to facilitate more effective monitoring of PAE and whether it has been inspected and at what intervals. Consider an exemption for low scale use handheld PAE and knapsack sprayers as already provided for in relevant provisions of Article 8 of the SUD	• *Both least ambitious options + the below* • **A2.1.ME.a:** Commission supports drift technology reduction tests, aiming to promote a more harmonised approach at EU level, the application of best available technologies (BATs) and the development of standards for PAE	• [...]
	• **A2.2**: Improve provisions on inspection intervals	• [...]	• **A2.2.ME.a:** Require all new PAE to be tested and certified latest between 6 and 12 months after purchase to avoid defects and problems might otherwise only be detected years subsequently	• [...]

12.4.2 *Impact from policy options addressing operational objective A2.1*

This section assesses the impacts from the policy options addressing the operational objective "Harmonise testing of pesticides application equipment across the EU".

The following policy options are assessed:

- **Least ambitions options:**
  - **A2.1.LE.a:** Further promote guidelines, harmonised methodology where CEN standards exist and stimulate knowledge sharing among Member States
  - **A2.1.LE.b:** Introduce a requirement for PAE to be registered to facilitate more effective monitoring of PAE and whether it has been inspected and at what intervals. Consider an exemption for low scale use handheld PAE and knapsack sprayers as already provided for in relevant provisions of Article 8 of the SUD
- **Medium ambitious options**:
  - **A2.1.ME.a:** A2.1.LE.a + A2.1.LE.b + Commission supports drift technology reduction tests, aiming to promote a more harmonised approach at EU level, the application of best available technologies (BATs) and the development of standards for PAE
- **Most ambitious options**:
  - n/a

Stakeholder opinions on harmonised testing of pesticides application equipment across the EU

The perspective of Member States differed regarding views on the promotion of guidelines, harmonised methodology and a requirement for PAE to be registered. No clear majority view was uncovered. Mandatory testing was broadly recognised to be an important tool in improving the efficiency of the use of PPP, however only eight Member States put forward strong support for the SUD to put in place further requirements in this area. Other Member States either did not state a preference, or made the point that PAE testing should be risk based and the specific types of machinery used (i.e. depending on the PPP that is being applied). Regarding harmonised methodologies, there was a consensus that further revision of the methodology would be beneficial in a revised SUD, utilising the evidence base from advice from SPICE[663].

For PPP users and industry, the proposed policy elements gathered some support, but comparatively less than other proposed elements. Both elements - requiring further harmonization for testing PAE and requiring all PAE to be registered at Member State level - gathered between 50%-53% (75 out of 150 respondents) support that they would lead to a reduced use and risk of chemical pesticides. Similarly, these elements gathered similar support of them being overly burdensome, with only half of respondents to the targeted survey answering to a major/moderate extent.

A similar view was observed for environmental NGOs and civil society organisations, with around 60% (14 out of 22 respondents to the targeted survey) being of the view that these policy elements would lead to the reduced use and risk of chemical pesticides to a major/moderate extent.

[663] Standardised Procedure for the Inspection of Sprayers

12.4.2.1 *Impacts from option A2.1.LE.a*

Direct economic impacts

Under the current SUD, Article 8 aims to ensure that pesticide application equipment in professional use is subject to inspections at regular intervals (3 years). In addition, it required Member States to ensure that pesticide application equipment has been inspected at least once before November 2016; after this date only pesticide application equipment having successfully passed inspection shall be in professional use. Article 8(4) (referring to general guidelines Annex II) then defines the requirements for testing pesticide application equipment.

As per Article 20 of the SUD, the European Commission established harmonised technical standards for testing application equipment. The standards have been published in 2015 and include the following[664]:

- Inspection of sprayers in use - Part 1: General (ISO 16122-1:2015)
- Inspection of sprayers in use - Part 2: Horizontal boom sprayers (ISO 16122-2:2015)
- Inspection of sprayers in use - Part 3: Sprayers for bush and tree crops (ISO 16122-3:2015)
- Inspection of sprayers in use - Part 4: Fixed and semi-mobile sprayers (ISO 16122-4:2015)

In addition, the SPISE Working Group has created a range of technical papers on inspection of spraying equipment where no ISO/CEN standards exist yet[665].

It should be mentioned that neither the ISO standards nor the SPISE recommendations are de facto mandatory to use, and national authorities are free to follow them or develop their own standards.

Also, no detailed overview exists of which countries have made which standards mandatory. Finally, and crucially, no structured comparison exists between the standards used in the countries (if different from ISO standards and SPISE advices) and the ISO standards and SPISE advices. Thus, it is not known to what extent national standards are more and which are less strict and stringent than ISO standards and SPISE advices. Thus, it is possible, that in some countries, the tests are stricter and more stringent than the ISO standards and SPISE advices. In which case, the European Commission should not promote the ISO standards nor SPISE advices, in order to avoid potentially having a negative impact on the environment and health. Thus, in the discussions below it is assumed that cost would only arise from stricter standards.

This policy option seeks to further promote those guidelines and standards and stimulate knowledge sharing among Member States.

European Institutions

In terms of promotion, there would be costs for the European Commission. However, since the types of promotion used are left open for the moment, the costs cannot be quantified. However, it can be expected that they would be fairly low, since promotion would likely involve outreach to national authorities, organisation of workshops with national authorities and development of studies and alike.

As mentioned above, no detailed overview exists on existing standards in the countries. In order to make sure that promotion only targets those countries with less stringent and strict standards in

[664] For more information see: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=uriserv:OJ.C_.2015.196.01.0004.01.ENG

[665] See: https://spise.julius-kuehn.de/index.php?menuid=34

place, the European Commission could develop a comparative overview on national standards, either with internal resources or through a procured study, which would add some costs.

National authorities

There are potential costs for actors in the countries if the national authorities that have not already done so, following the promotion, would decide to adapt the ISO standards or the SPISE advices. However, it is not a given that this would happen. Where this is the case, there would be costs for the national authorities, control institutions[666], and farmers.

National authorities are responsible for the control of sprayer and are in charge of the administration of a control and certification system (if applicable). Changed requirements stemming from the adoption of ISO standards or SPISE advices are expected to be of technical nature (e.g. concerning thresholds or testing methods) and may lead to administrational efforts for the implementation, organisation and management of certification and control. However, those can be expected to be low since they only involve the adaptation of the current system.[667]

In addition, input from national authorities on the policy options relating to the PAE uncovered that for some Member States, processes are already underway to align with the option to adopt existing harmonised methodologies, thus it is assumed that for these countries that the adoption of this option would not cause significant direct economic costs.

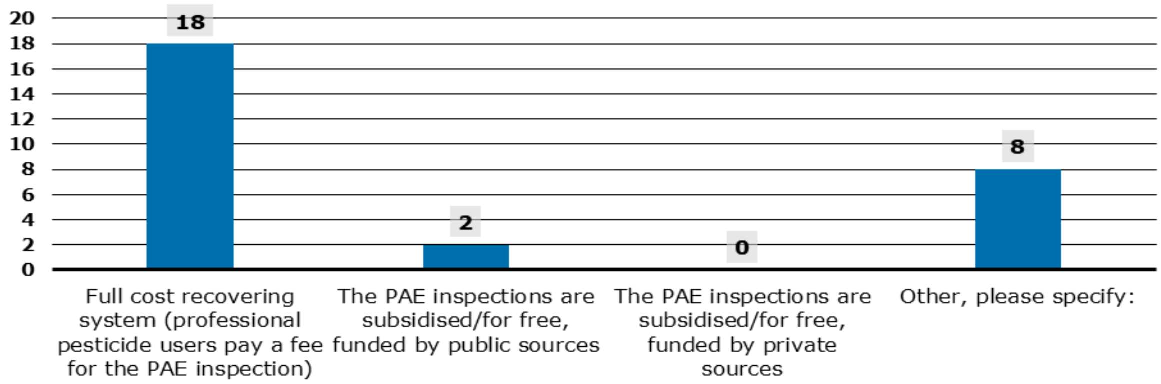
Other stakeholders: control institutions

Control institutions would face costs from adapting to potentially changed standards which could range from changing routines/processes with very little costs to buying of new equipment or hiring of new staff which would lead to higher costs. However, the evaluation has shown that in the majority of cases the costs of inspections are fully recovered through fees as shown in the Figure below.

[666] Control institutions are in charge of testing the spraying equipment in use and assigning of proof if a sprayer has passed the inspection successfully. Such institutions are either supported by authorities as public institutions or organised as private companies

[667] As point of comparison, the evaluation found that countries only faced low costs for setting up the system for testing spraying equipment – also due to the fact that most countries already had systems in place, albeit the changes introduced then (through the current SUD) can be considered to be more impactful than the changes suggested through this policy option.

Figure 12.2 Survey with MS authorities: *Please provide an overview of how the inspection system is financed (e.g. through fees, taxes).*[668]



Source: Own illustration based on results from survey with Member State officials

This implies that any potential costs in those countries would be transferred to the owners of the inspection equipment. In countries where the testing system is covered by public funding this might lead to an increase in cost for the public bodies.

Farmers and other owners of PAE

In countries where the costs for inspections are fully recovered through fees this could lead to an increase in fees. However, it is expected that this increase would be negligible.

Concerning the current prices per inspection, most estimates provided[669] through the survey with Member State authorities[670] range between 25 and 150 EUR. Four replies highlight that the costs depend on several factors such as the equipment, travel cost (distance to farm) or the inspection company. A detailed account of average costs per inspection is also provided by the SPISE working group[671] in the workshop report of the 7th SPISE workshop, held in 2018 in Athens[672]. Estimates range from 50 to 500 EUR per inspection. As can be seen from both sources, costs differ considerably between Member States.

Concerning potential additional costs from the policy option, the main potential costs would be from buying of new equipment or hiring of new staff in countries that decide to adopt (stricter) ISO standards or SPISE advices. As per latest available data, there are approximately 3,000 authorised workshops or teams (i.e., control institutions) in the EU.[673] The same source also estimated that approximately 2.7 million sprayers liable for inspection. Thus, on average, each control institution is responsible for testing approximately 900 sprayers (translating into about 300 per year), which means that potential additional costs could be spread over a large base of owners of PAE, limiting the cost per owner.

[668] In the "other" category two replies pointed out regional differences. Other replies describe that there is a mix of public subsidies and private fees.

[669] Ten replies

[670] Question: *Please provide an estimation of the average cost for an inspection of PAE?*

[671] "The Standardised Procedure for the Inspection of Sprayers in Europe" Working Group.

[672] See: https://www.openagrar.de/servlets/MCRFileNodeServlet/openagrar_derivate_00016900/JKI_Bericht_196_Druckdatei.pdf p.12 f

[673] See: Wehmann, H. J. (2018). Status Quo of Inspection in EU: The Results of SPISE Enquiry. In 7th European Workshop on Standardised Procedure for the Inspection of Sprayers–SPISE 7. Athens, Greece. (September 26–28, 9–22).

Numbers of UK workshops and teams have been deducted from the estimations

In addition to the inspection itself, farmers might also face additional cost for repairs and maintenance. The SPISE report cited above provides information on the percentage of inspected sprayers with a defect with an average of around 50%[674]. The numbers show that there seems to be a large percentage of PAE that requires repairs. While some of those repair costs may occur anyway, it is likely that others are needed to pass the inspections following stricter standards.

On the other hand, users could benefit from inspection and related repair/optimisation of their sprayers since it is possible that those lead to a use reduction of pesticides which in turn provides savings on the costs for pesticides. The 2004 impact assessment preceding the SUD mentioned in this regard the following: "*As a result of discussions with several experts during and in the follow up of the SPISE workshop […] the average PPP use reduction potential resulting from regular control is estimated to range from 5 to 10%*". It should be noted that those numbers could neither be verified nor falsified through expert opinions and is thus considered to still be the best available assumption.[675]

However, the assumption was made in the context of estimating the benefits from introducing regular inspections (where there were not inspections before) as compared to the policy option at hand which aims at improving standards in some countries where regular inspections are already done. Thus, it can be expected that the savings would be considerably lower. Despite this, the targeted survey to PPP users and industry identified division on the extent to which the harmonization for testing PAE would result in increased burden/ costs. Overall, 74 out of 150 respondents answered that it would be overly burdensome/ costly while 51 noted that the impacts would be minimal. This finding further adds to the ambiguity on the degree to which this option would bring about positive or negative costs to farmers and other owners of PAE.

Other impacts (environmental, social, macroeconomic)

Periodical PAE inspections were identified as being a key aspect for improving pesticide application in the evaluation. This was also found in several scientific articles[676], where the importance of testing and inspections of equipment was found to be of great importance for the protection of human health and the environment, e.g. since it has large potential to reduce spray drift. For example, the study carried out by Stas, et.al (2017) of PAE testing in Belgium found that PAE types already inspected in Belgium, including inspections of PAE for field crops, orchards, fixed and semi mobile and disinfection equipment proved to be the most effective in reducing the risks to human health and the environment (i.e., residual risk).

At a broader level, findings from the targeted survey to NGOs, environmental organisations and consumer organisations found general agreement that the implementation of this option could help to lead to a reduced use and risk of chemical pesticides to a major/ moderate extent (14 out 22 organisations).

[674] Those percentages differ considerably and range from 5 to 92 % and the report states that it is likely that the question might have been misunderstood by some respondents to the survey underlying the report

[675] However, it should be noted that the evaluation could also not confirm this assumption. On the contrary, it was found that, given that sales of pesticides have not decreased since the SUD was adopted while the volume of agricultural production also remained relatively stable , it can be assumed that those savings were not realised or only partly realised.

[676] Stas et.al (2017). New approach to fulfil art 8 of Directive 2009/128: a risk assessment procedure for pesticide application equipment, Dimitrovski (2017). Inspection of pesticide application equipment, Cerruto, Manetto, Longo and Papa (2020). Sprayer Inspection in Sicily on the Basis of Workshop Activity

12.4.2.2 *Impacts from option A2.1.LE.b*

Direct economic impacts

Currently, no obligation exists at EU level (from SUD or other legislation) to register sprayers. Through the survey with national authorities, half of the respondents said that they have a system in place, while the other half mentioned that they do not currently.

Information was provided by some respondents on the governance of the registration systems. For example, in Spain, the national government provides the infrastructure[677] and it is the responsibility of the owners of PAE to register their equipment in the register when they buy a new PAE. Since this thus only concerns new PAE, Article 4 of Royal Decree 1702/2011 requires the competent authorities of the autonomous communities to run a survey of equipment to be inspected within their geographical area, covering all the equipment to be inspected.

In Cyprus, since November 2020, it is requested from all professional users applying for issuance or renewal of their certificates, to register their PAE via an online government platform.

In Sweden, no formal registration system is in place, but it is linked to the inspections. The Swedish system for the approval of pesticide equipment is a further development of the voluntary system in place since 1988. The system is for non-exempted sprayers being inspected. In addition to checking that the equipment complies with the harmonized standard, the inspection may also include calibration, other advice and repairs. This is typically invoiced on a common invoice. The Swedish Board of Agriculture then approves the PAE with the protocol from the inspection as a basis. Therefore, the Swedish Board of Agriculture knows which approval decisions have been made but does not register the PAE itself.

The sections below discuss the potential costs for the different stakeholders stemming from this policy option. The discussion assumes that there will be an exemption for low scale use handheld PAE and knapsack sprayers (as already provided for in relevant provisions of Article 8 of the SUD) as suggested by the policy option since it is very likely that this exemption would be included in the final text, given that the exempted equipment does not have to be tested and the added value of their registration would be very low.

National authorities

Based on the above it can be seen that approaches vary widely in the existing registration systems in terms of governance and consequently the question of who bears the costs. The policy option does not prescribe a specific governance model and thus the costs faced by the different actors would vary widely.

However, some costs would occur for national authorities for the creation of the national infrastructure (i.e., creation of a platform or integration of existing platforms and then maintenance) which would, however, be relatively low and thus it is not attempted to quantify them. Through case-based fact finding, indicative costs for national authorities which have implemented a PAE register are presented below.

[677] In the form of the official registers of agricultural machinery (ROMA) established by Royal Decree 1013/2009, of June 19, on characterization registration of agricultural machinery

Table 12-11. Indicative costs for existing PAE registration schemes[678]

Member State	Description	Cost for implementation	Cost for monitoring
Belgium	Established in 1995 1st system established in paper format 2nd system updated 2007 to electronic submission (online app)	1st system in paper format: 5 days FTE 2nd system of electronic submission: 50 days FTE	Maintenance time minimal. Monitoring of the data approx. one FTE.
Cyprus	Developed as an e-government platform. System was developed to cover both PAE registration and applications for renewal/issuance of professional certification.	Approx. 41 days in total Five months of work divided between 4 staff working 1/3 of the time on implementation.	4 FTE per month for monitoring and maintenance
Slovenia	Established in 1998. Currently 16600 PAE are registered Records updated by PAE inspectors only	Not possible to estimate.	Approximately EUR 6000 per year

Additional costs for national authorities depend again on the governance model. If (like in Spain) only newly acquired PAE would have to be self-registered by the owners, it would not create any further costs for the authorities.

If, however, it is part of the policy option (through a cut-off date or an additional provision) that all registers must be registered, including the registered stock, this would likely create additional costs for the national authorities. Different pathways taken to achieve this would again entail different costs. For example, if a survey is used (like in Spain), this would likely create some costs which are, however, expected to be low if done through online forms.

Other options include a specific campaign in which inspectors visit all farms to take stock of PAE, which would create considerable costs. However, since this is not required as part of the policy option and there are more elegant and less costly ways, it is unlikely that any Member State would take this route.

Farmers and other owners of PAE

Again, the costs for owners of PAE would to some extent depend on the governance structure selected by the respective national authority. However, since registration would only take very limited time and would be a one-off cost (either when buying new equipment or through a survey) those costs can be considered negligible. Despite this, the targeted survey to PPP users and industry identified division on the extent to which the registration of PAE would result in increased burden/ costs. Overall, 78 out of 150 respondents answered that it would be overly burdensome/ costly while 48 noted that the impacts would be minimal. This finding further adds to the ambiguity on

[678] Information gathered through case-based fact finding to Member State authorities

the degree to which this option would bring about positive or negative costs to farmers and other owners of PAE.

Other impacts (environmental, social, macroeconomic)

As mentioned in chapter 12.4.2.1 above, inspection and repairing of PAE has great potential for creating environmental and health benefits. This policy option would be an enabling factor to this by ensuring, that all PAE are inspected. This is emphasised by the fact that to the survey with national authorities estimate in three cases that only below 50% of all sprayers have been tested and an additional four that between 50% and 75% have been tested. Thus, there is large potential for the testing to be more effective if Member States get a better understanding of the PAE stock in their country. Also the 2018 SPISE Survey[679] concludes that the lack of national PAE registers limits the ability to effectively carry out inspections.

At a broader level, findings from the targeted survey to NGOs, environmental organisations and consumer organisations found general agreement that the implementation of this option could help to lead to a reduced use and risk of chemical pesticides to a major/ moderate extent (14 out 22 organisations).

12.4.2.3 *Impacts from option A2.1.ME.a*

Direct economic impacts

This policy option predominantly would create costs for the European Commission by providing funding for drift technology reduction tests, aiming to promote a more harmonised approach at EU level, the application of best available technologies (BATs). While it can be expected that those costs would be high, they cannot be estimated since there are several options. However, it is likely that funding would be provided through research funds (e.g. Horizon Europe or others), thus benefiting institutes and other actors eventually working on the projects.

As noted in section 12.4.2.1, it should be mentioned that no structured comparison exists between the standards used in the countries (if different from ISO standards and SPISE advices) and the ISO standards and SPISE advices. Thus, it is not known to what extent national standards are more and which are less strict and stringent than ISO standards and SPISE advices. Thus, it is possible, that in some countries the tests are stricter and more stringent than the ISO standards and SPISE advices, in which case the European Commission should not promote the ISO standards and SPISE advices in order to not potentially have a negative impact on the environment and health. Thus, in the discussions below it is assumed that cost would only arise from stricter standards.

Resulting from this, it is likely that the European Commission would first produce an overview of existing standards in the countries, creating some additional costs.

12.4.3 Impact from policy options addressing operational objective A2.2

This section assesses the impacts from the policy options addressing the operational objective "Improve controls and apply harmonised standards".

The following policy option is assessed:

- **Least ambitions options:**

[679] Wehmann, H. J. (2018). Status Quo of Inspection in EU: The Results of SPISE Enquiry. In 7th European Workshop on Standardised Procedure for the Inspection of Sprayers–SPISE 7. Athens, Greece. (September 26–28, 9–22)

    - n/a
- **Medium ambitious options**:
    - **A2.2.ME.a**: Require all new PAE to be tested and certified latest between 6 and 12 months after purchase to avoid that defects and problems might otherwise only be detected years subsequently
- **Most ambitious options**:
    - n/a

Stakeholder views on improving controls and applying harmonised standards

From the perspective of Member State authorities, a similar view was presented as to previous PAE policy elements (see section 12.4.2). In particular, there was broad support for the inspection of PAE equipment, however there was a recognition that this could lead to increased financial burden on farmers in the short term. However, the long-term economic benefits of such a process would be apparent to farmers. With regards to social and environmental benefits, Member State authorities were not able to state any clear benefits that could be anticipated following implementation of this policy element. One recurring point that was raised however, with the coherence of the SUD and the Machinery Directive (2006/42/EC), whereby there is the view that increasing the testing and certification of PAE encroaches upon the provisions set in the Directive 2006/42/EC.

Similar to the previous policy elements described in the section 12.4.2, PPP users and industry and environmental NGOs largely agree that testing of PAE is an appropriate tool to aid a reduction in the risk and use of chemical pesticides. However, this position was comparatively less supported by PPP users compared to other stakeholder groups.

12.4.3.1 *Impacts from option A2.2.ME.a*

Direct economic impacts

Currently, new PAE is be expected at least once within a period of five years after purchase. Thus, this policy option would shift this date forward by 4 - 4.5 years. After that, each PAE has to be inspected at last every three years.

It should be noted that all new sprayers must comply with certain standards[680]when they leave the factory. This is governed by the Machinery Directive[681], which should ensure that they meet requirements of inspections. However, insights e.g. from Germany (which tests all PAE after six months)[682] show that there is an issue of more sprayers of the low-price segment appearing in the market. These sprayers are often equipped poorly, and sometimes fail to be in line with the relevant standards. Also, as replies to the survey with national authorities suggest, controls after five years often already unveil a need for repairs which would point to the need of having earlier controls.

No considerable costs are expected from this policy option, given that PAE is usually in use for several years (estimated is an average of ten years, based on expert judgement) and thus over the lifetime of the equipment the costs for this test would not be high (or it would not be an additional

[680] This includes the standards under ISO 16119 which define environmental requirements for different types of sprayers

[681] Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast) (Text with EEA relevance). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0042

[682] See section "Inspection of new sprayers – defects following EN-ISO 16119/16122" in the Sixth European Workshop on Standardised Procedure for the Inspection of Sprayers in Europe - SPISE 6. See: https://spise.julius-kuehn.de/dokumente/upload/SPISE_6-Book_of_proceedings-Barcelona.pdf

test if equipment is replaced at certain times during the intervals). If it is assumed (based on the ten-year life expectancy) that over the lifetime of a PAE on additional test must be conducted and that a test on average costs 180 EUR[683], this would mean an additional 18 EUR of annual costs per farmer.

Those would translate into additional benefits for controlling institutions who otherwise would not face any additional costs. This assumes, however, that this provision would not apply directly but only in a number of years (e.g., 3 years after the adoption of a revised SUD) to avoid bottle necks at the testing institutions.

Other impacts (environmental, social, macroeconomic)

Due to the likely effect of detecting needs for repairs and non-compliant PAE earlier, it can be expected that this policy option could contribute to environmental and social benefits.

12.4.4 Comparison of options to improve controls and apply harmonised standards (specific objective A2)

[683] Based on figures presented in section 12.4.2.1

Table 12-12 Comparison of options improve controls and apply harmonised standards (specific objective A2)

	A2.1.LE.a	A2.1.LE.b	A2.1.ME.a:	A2.2.ME.a
Impacts				
Professional users and other owners of PAE	**Additional costs for inspections due to higher standards: (/ to -)** *Applies only if national authorities decide to change national standards following promotion. In most countries, the testing system is fully financed through fees in which case the additional costs would be transferred to the owners of PAE. However, due to the favourable ratio of farmers to inspection institutions the additional costs would be spread over a large group and would thus be low* **Potential for saving on expenses for pesticides: (++)**	**Registration: -** *Independently from the actual governance system that countries choose, in any case the professional users would face very little cost.*	**/**	**Costs for approximately one additional test over the lifetime of an PAE: -**
National authorities	**Cost for adopting new standards: (-)** *This only applies to countries that would decide to change their testing standards following the promotion of the European Commission*	**Registration: - to --** *Costs depends highly on the governance system chosen. If a cut-off date is introduced by which a full overview has to be available, some costs would occur for the stock-taking (e.g. through a survey)*	/	
European Institutions	**Cost for promotion: -** **Costs for developing an overview for existing standards in the countries:**	/	**Costs from provided funding: - to –** **Costs for developing an overview for existing**	

	A2.1.LE.a	A2.1.LE.b	A2.1.ME.a:	A2.2.ME.a
	(-)[684] *This would be a preparational measure for this policy option to ensure relevance*		**standards in the countries: (-)**[685]	
Other stakeholders	**Control institutions: (/ to -)** *Higher costs due to higher standards. Applies only if national authorities decide to change national standards following promotion. In most countries, the testing system is fully financed through fees in which case the costs would be neutral since they would be transferred to owners of PAE*	/	/	**Control institutions: +** *Benefits from approximately one additional test over the lifetime of an PAE*
General society (Environmental. social, macroeconomic impacts)	**Environmental and social benefits: (++)** *From better spraying equipment resulting e.g. in less spray drift and potentially also in a reduction of use of pesticides*	*(Environmental and social benefits, however only indirectly since this policy option is only an enabler for better testing)*	*(Environmental and social benefits, however only indirectly since this policy option is only an enabler for better testing)*	**Environmental and social benefits: (++)** *From better spraying equipment resulting e.g. in less spray drift and potentially also in a reduction of use of pesticides*
Other criteria				
Effectiveness	**+ to ++** *Effectiveness depends on the baseline which currently is unknown. The EC should make sure to not promote lower standards than in some countries and thus should consider as preparatory action to develop a detailed baseline.*	**+++** *Given the gaps in testing still today (partly due to a lack of an overview of PAE in the countries) and the potential benefits from eventual testing this option can be considered very effective.*	**+ to ++** *Effectiveness depends on the baseline which currently is unknown.*	**+++** *Expected to be very effective in early identification of low-quality PAE not in line with ISO standards as well as of need for repairs*

[684] Same as in policy option A2.1.ME.a

[685] Same as in policy option A2.1.LE.a

	A2.1.LE.a	A2.1.LE.b	A2.1.ME.a:	A2.2.ME.a
Coherence	*No coherence issues*	*No coherence issue*	*No coherence issue*	*No coherence issue if required after initial use. Provisions for new machinery placed on the market are set in Directive 2006/42/EC.*
Efficiency	**++ to +++** *Again, this is linked to the factors described in effectiveness. However, given that costs would be relatively low and there is the potential for a good effect this policy option could be highly efficient.*	**+++**	**+ to ++** *Also efficiency depends on the baseline which currently is unknown.*	**+++**
Proportionality	**+++** *The low administrative burden for all stakeholders means that this would be a proportionate measure.*	**+++** *The PAE register would support the control of SUD provisions on such equipment at relatively low costs.*	**+++** *Proportionate as low administrative burden is created*	**+++** *Proportionate as the additional administrative burden is justified by additional benefits from ensuring that PAE used is well-funcitoning also when relatively new.*
Subsidiarity	No issues	No issues	No issues	No issues

/: no impact
Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)
(): brackets if costs, benefits etc. are only potentially
If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +
The green coloured cells pertain to the preferred option of the Commission

12.5 Impact from policy options addressing the effectiveness of the NAPs equipment (specific objective A3)

12.5.1 Overview

The table below summarises the options for achieving this objective.

Table 12-13 Policy options for addressing the specific objective

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitious option
A3: Strengthen effectiveness of the NAPs	• **A3.1**: Ensure high level of ambition in all NAPs	• **A3.1.LE.a:** Legislation provides for more specificity as to what is included in NAP • **A3.1.LE.b:** Commission takes stronger line in enforcement of existing requirement and in links to target	• *Both least ambitious options + the below* • **A3.1.ME.a:** Template provided on NAP structure and improved Commission guidance on NAP reporting, including reduction of use and risk for health and environment	• […]
	• **A3.2**: Ensure more frequent reporting from MS	• […]	• **A3.2.ME.a:** Reporting on NAPs has to take place **annually**, including monitoring progress related to F2F targets and outcome of HRI trends[686]	• […]

12.5.2 Impact from policy options addressing operational objective A3.1

This section assesses the impacts from the policy options addressing the operational objective “Strengthen effectiveness of the NAPs”.

The following policy options are assessed:

- **Least ambitions options:**
  - **A3.1.LE.a:** Legislation provides for more specificity as to what is included in NAP
  - **A3.1.LE.b:** Commission takes stronger line in enforcement of existing requirement and in links to target
- **Medium ambitious options**:
  - **A3.1.ME.a:** A3.1.LE.a + A3.1.LE.b + Template provided on NAP structure and improved Commission guidance on NAP reporting, including reduction of use and risk for health and environment
- **Most ambitious options**:
  - n/a

[686] See also links with options on F2F targets below

Stakeholder views on strengthening the effectiveness of the NAPs

From the perspective of Member State authorities, there was some degree of support for further guidance on NAP structure and reporting, however a recurring view across Member States was for there to be stronger links between the NAPs and the CAP. Despite this, NAPs were perceived by Member States to be a good instrument to support the implementation of the SUD at the national level (81% of respondents to the targeted Member State survey, or 25 out of 27 Member States).

12.5.2.1 *Impacts from option A3.1.LE.a*

Direct economic impacts

The direct economic impacts of this option depend strongly on what specifically the legislation provides for. If new requirements for NAPs are added and specified, this cannot be quantified at this stage, as the requirements are left open.

If specificity is provided for currently required elements of the NAP, relatively minor costs would arise at the level of the EU Commission for drafting, agreeing and communicating the specifications. Some Member States would have additional costs from revising their NAP to meet the legal specifications. The costs would be largely similar to option A3.1.LE.b and will be discussed in Section 12.5.2.2.

Other impacts (environmental, social, macroeconomic)

Specific impacts could arise for different groups of stakeholders depending on the specifications for NAPs provided in the legislation. On the one hand, these could lead to higher ambition in Member States and subsequently stronger measures to achieve such targets.

12.5.2.2 *Impacts from option A3.1.LE.b*

Direct economic impacts

The stronger enforcement of existing requirements would result in costs for Member States which do not comply with the requirements at present. Implementing the requirements of the SUD is not a new obligation to Member States and can therefore not be qualified as new, additional impacts on Member States, pesticide users or other stakeholders. However, a general high-level assessment of costs for Member States is relevant, depending on the status of the existing NAPs and the extent to which they comply with the requirements of the current SUD.

The report on experiences gained from Member States in respect to the NAPs as well as the case study conducted on NAPs reveals that very few Member States fully comply with all requirements and would therefore risk facing enforcement procedures. In particular, quantified targets for risk and use reduction have been adopted by only four Member States[687]. The Commission had identified the shortcomings in quantitative targets and overall ambition in a review of NAPs, but "most Member States have not addressed the weaknesses identified"[688]. A revision of the NAP is required every 5 years by the SUD. Some Member States have not completed a revision so far, while for a majority

[687] Denmark, Germany, France, and Luxembourg

[688] European Commission, "On the Experience Gained by Member States on the Implementation of National Targets Established in Their National Action Plans and on Progress in the Implementation of Directive 2009/128/EC on the Sustainable Use of Pesticides." European Commission.

the next revision is foreseen for either 2022 or 2023[689]. This means that no additional costs would arise for Member States if these requirements were overlapping for the next revision.

Therefore, even though no new requirements are introduced, in practice costs can be expected for most Member States on revising their NAP to include such targets. Based on the average of responses by Member States to the targeted survey, the costs for 1 FTE arise in the process of developing a NAP. For a revision of parts of the NAP a lower figure can be expected, but noticeable costs will arise from consultation and negotiation activities with stakeholders and other relevant authorities. Some Member States indicate concern in the targeted survey about increased formal requirements that take time from actively managing and implementing the measures that current NAPs contain.

The activity of enforcing the requirements for NAPs towards the Member States would lead to costs in the EU Commission for auditing Member States, preparing formal letters and processing of replies by legal experts.

Other impacts (environmental, social, macroeconomic)

Similar to option A3.1.LE.a above, the other impacts of this policy option depend on the targets and provisions included in the NAP. On the one hand, these could lead to higher ambition in Member States and subsequently stronger measures to achieve such targets.

12.5.2.3 *Impacts from option A3.1.ME.a*

Direct economic impacts

In addition to the costs mentioned in sections 12.5.2.1 and 12.5.2.2, national authorities would face costs for adapting their NAPs from the current format to the template and reporting guidance. Since the content and format as well as the legal status of the template and guidance is not known, quantifying the direct impacts for Member States is impossible.

However, as NAPs vary considerably in format, volume and detail, as well as the process leading to its adoption[690], an alignment of NAPs to a standardised format would lead to costs in all Member States, in the authorities developing the NAP. The distribution of costs across Member States would follow a similar structure as described for option A3.1.LE.b, because it can be expected that Member States with higher fulfilment of current NAP requirements, can more easily adapt their NAP to the new template.

As this option includes both options assessed before (options A3.1.LE.a and A3.1.LE.b), the additional costs to those options would be small, as an adjustment of the NAP would be needed for most Member States in response to the two previous options. In sum, however, noticeable costs of medium magnitude can be expected in Member States competent authorities to align their NAPs. The exact order of magnitude and distribution would depend on the form and content of the template.

For the EU Commission, additional one-off costs for developing the template would arise.

[689] See Table 4.2 in the evaluation report

[690] See case study on NAPs

Other impacts (environmental, social, macroeconomic)

Other impacts are largely similar to the ones described for options A3.1.LE.a and A3.1.LE. Some Member States point out in the targeted survey that a uniform template would lead to ignoring specific national or regional conditions and characteristics that can be better expressed in an open format of a NAP. However, this risk can be mitigated by a carefully designed template.

12.5.3 Impact from policy options addressing operational objective A3.2

This section assesses the impacts from the policy options addressing the operational objective "Ensure more frequent reporting from MS".

The following policy option is assessed:

- **Least ambitions options:**
  - n/a
- **Medium ambitious options**:
  - **A3.2.ME.a:** Reporting on NAPs has to take place annually, including monitoring progress related to F2F targets and outcome of HRI trends
- **Most ambitious options**:
  - n/a

Stakeholder views on ensuring more frequent reporting from MS

Overall, Member States presented diverging views on the effectiveness of reporting on NAPs to take place annually. In particular, while several Member States disagreed with the option for annual reporting, a small number of Member States pointed that a more flexible approach could be adopted, however this would require the Commission to set clear standards and guidelines to what would be expected.

12.5.3.1 *Impacts from option A3.2.ME.a*

Direct economic impacts

National authorities

The current provisions on NAPs require Member States to review their plans every five years (Article 4 Paragraph 2) and report on the harmonised risk indicators, trends in active substances, as well as other priority items to the Commission and the public (Article 15 Paragraphs 2 and 3). The adoption of this policy option would add additional yearly reporting requirements on other elements of the NAP, including monitoring information on the F2F pesticide targets and the HRIs.

Direct economic impacts would arise for Member States to collect the information and report on it to the Commission. Yearly reporting to the public could be part of the option as well but is not explicitly mentioned.

Table 12-14 Overview of quantitative estimations of costs for national authorities

Name	Type	Assumptions	Costs	Distributional considerations
Data collection and reporting	Recurring annually	• It is assumed that the 6 Member States with existing national annual reporting obligations have minor costs. With those Member States also	Approximately 630 000 EUR	• Countries with existing national obligations for annual reporting face

Name	Type	Assumptions	Costs	Distributional considerations
		more likely to respond to the survey question, the assumed number of Member States with noticeable costs is assumed at 20. • It is assumed that other Member States require resources at the lower end of the spectrum of estimations for and evaluation and revision of the NAP, resulting in 0.5 FTE required.		lower costs than countries with no such obligation at the moment

Impacts on Member States depend on the current reporting system of the country. Based on the survey responses made by national authorities, Member States can be grouped into two categories[691]:

- Ones that already have national reporting obligations and therefore do not expect substantial additional costs; and
- Ones that do not presently report at such frequency and therefore expect relevant additional costs for relevant authorities.

The first group is smaller and comprises Belgium, Czechia, Denmark, Germany, France and the Netherlands. These Member States see only minor additional costs as long as the reporting covers high-level information on the elements of the NAPs and indicators based on sales data. However, should detailed requirements be made, or a translation to English be required, costs would also arise for these Member States.

In the remaining Member States, structures for annual reporting would have to be established. This would lead to additional human resources needed for the collecting the data and drafting the report. Nine Member States indicate the additional burden this would cause is substantial but not directly quantifiable. Yearly reporting is assumed to be less labour-intensive than revising the NAP, but due to data collection and reporting, considerable work is still needed. Therefore, the time assumption is made at the lower end of the spectrum of estimations for the evaluation and revision of a NAP. Thus, 0.5 FTE are assumed to be needed in 20 Member States (building on the fact that some Member States already have reporting mechanisms but those were more likely to reply to the survey.

Professional users

As the monitoring of certain measures of some NAPs is based on surveys with professional users, additional time requirements would arise for these as well, if yearly surveys would be needed. Only one Member State indicated this concern in the survey, but others may not have such a system yet, because systematic monitoring and reporting is not undertaken. The costs are therefore difficult to quantify. However, they would be driven by the measures of the NAP, the time needed to respond to such a survey and the number of farmers in that Member State.

In case of a survey to professional users, a combination of two elements is assumed based on the existing mechanism in place in Sweden:

- a short online questionnaire on elements such as PAE used or storage of pesticides that takes about 15 minutes to complete; and

[691] It should be noted that not all Member States have responded to the survey and not all responses contained an assessment of potential costs. The number of Member States for which an assessment was reported is 16.

- an extensive survey followed by an interview on pesticides used, crops, doses, etc., which in total requires 2.5 hours to complete.

Table 12-15 Overview of quantitative estimations of costs for professional users

Name	Type	Assumptions	Costs	Distributional considerations
Input to NAP monitoring through surveys or interviews	Recurring annually	• It is assumed that 5% of all farmers in a Member State answer the two consultation elements every year, based on estimations of the Swedish consultation. • It is assumed that responding to the consultation requires in total 2.75 hours. • An average hourly labour cost of 12 EUR is assumed[692]	Approximately 165 000 EUR per 100 000 farmers	• The costs would only apply to countries with elements in their NAP that require monitoring through consultation with users • Total costs depend on the number of farmers in the Member States using such a tool.

Other impacts (environmental, social, macroeconomic)

The requirements for annual reporting on progress on the NAPs and indicators would require more frequent monitoring of the trends and effects of the measures included in Member States NAPs. More frequent monitoring would also allow see trends quicker and have time to react. This would lead to improved understanding of the effectiveness for policymakers and the public for informed decisions on the measures to achieve a risk and use reduction of pesticides, which would lead to indirect social and environmental benefits.

On the other hand, Member States also mention the limited resources available to the implementation of NAP measures, which could get even more limited through additional reporting requirements. As such, potential effects described for options A3.1.LE.a and A3.1.LE.b are also applicable for this option.

12.5.4 Comparison of options to strengthen effectiveness of the NAPs (specific objective A3)

[692] See Footnote 622

Table 12-16 addressing the options to strengthen effectiveness of the NAPs (specific objective A3)

	A3.1.LE.a	A3.1.LE.b	A3.1.ME.a:	A3.2.ME.a
Impacts				
Professional users	**/**	/	**/**	**/**
National authorities	**Additional costs for revisions based on specific instructions: -**	*(There would be some costs for Member States with limited compliance so far; implementing the requirements of the SUD is not a new obligation to Member States and can therefore not be qualified as new, additional impacts on Member States)*	**Additional costs for revisions based on specific instructions: --**	**Data collection and reporting: -** *approx. 630k EUR annually*
European Institutions	**Costs for definition of specifications: -**	**Costs for enforcement: -**	**Costs for preparation of template: -**	**Input to NAP monitoring through surveys or interviews: -** *Approximately 165k EUR per 100,000 farmers*
Other stakeholders	/	/	/	/
General society (Environmental. social, macroeconomic impacts)	/	/	/	/
Other criteria				
Effectiveness	**+** *Limited effectiveness since it is likely that national authorities still would have fairly different*	*(There would be some costs for Member States with limited compliance so far; implementing the requirements of the SUD is not a new obligation to Member*	**++** *Higher effectiveness since it is likely that the quality of the NAPs would increase as week as their comparability.*	**+** *Annual reporting would lead to closer policy monitoring. However, since most of the proposed policy options would*

	A3.1.LE.a	A3.1.LE.b	A3.1.ME.a:	A3.2.ME.a
	approaches to the NAPs which would hamper comparability.	*States and can therefore not be qualified as new, additional impacts on Member States)*		*take time to be implemented and then likely even longer to show impacts, it can be assumed that effectiveness of this measures is somewhat limited. However, it might increase alertness in the countries and thus bring the issue of the sustainable use of pesticides closer to the attention of some stakeholders.*
Coherence	*No coherence issues*	*No coherence issues*	*No coherence issues*	*No coherence issues*
Efficiency	**++** *Good efficiency since, even though effectiveness is low, the costs are also low*	*(There would be some costs for Member States with limited compliance so far; implementing the requirements of the SUD is not a new obligation to Member States and can therefore not be qualified as new, additional impacts on Member States)*	**++**	**+**
Proportionality	**+++** *Considered highly proportionate .*	**+++** *Considered highly proportionate .*	**+++** *Considered highly proportionate .*	**+++** *Considered highly proportionate .*
Subsidiarity	No issues	No issues	No issues	No issues

/: no impact
Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)
():brackets if costs, benefits etc. are only potentially
If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +
The green coloured cells pertain to the preferred option of the Commission
The blue coloured cells pertain to the option that was assessed positively from the Assessment

12.6 Impact from policy options addressing training obligations (specific objective A4)

12.6.1 Overview

The table overleaf below summarises the options for achieving this objective. Table 12-17 Policy options for addressing the specific objective

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitious option
A4: Improve expertise of pesticide users	• **A4.1:** Make training for pesticide users mandatory	• **A4.1.LE.a:** All **operators** of PAE (i.e. pesticide users) to hold a certificate of training **instead** of the current requirement that only the purchaser of the pesticides be trained (i.e. delete current requirement for a training certificate to purchase a pesticide, instead introduce requirement for a training certificate to use pesticides since this is the riskier element rather than merely purchasing a pesticides)	• […]	• […]

12.6.2 Impact from policy options addressing operational objective A4.1

This section assesses the impacts from the policy options addressing the operational objective “Make training for pesticide users mandatory”.

The following policy options are assessed:

- **Least ambitions options:**
- **A4.1.LE.a:** All operators of PAE (i.e. pesticide users) to hold a certificate of training instead of the current requirement that only the purchaser of the pesticides be trained (i.e. delete current requirement for a training certificate to purchase a pesticide, instead introduce requirement for a training certificate to use pesticides since this is the riskier element rather than merely purchasing a pesticides)
- **Medium ambitious options**:
- n/a
- **Most ambitious options**:
- n/a

Stakeholder views on making training for pesticide users mandatory

From the perspective of Member State authorities, an overarching view was that placing a requirement on pesticide users to hold a certificate of training could lead to some administrative burden both at the national and farm levels. The impact of this policy element was also unclear in terms of the environment and social impacts it could achieve. Despite this, as most Member States have a certification system in place, it was seen that this policy element would not be costly for all Member States.

For environmental NGOs and civil society organisations, there was a strong view that this policy element would be effective to a major/moderate extent in reducing the use and risk of chemical pesticides (18 out of 22 respondents to the targeted survey). Interestingly, this view was shared by PPP users and industry, where 108 out of 151 respondents (from the targeted survey) were of the view that this would lead to a reduction in the use and risk of chemical pesticides, to a major/ moderate extent. Similarly, the proposed policy element was not seen to impose significant administrative burden.

12.6.2.1 *Impacts from option A4.1.LE.a*

Direct economic impacts

Currently almost all Member States[693] have training schemes in place and require training and certification of all professional users, not only the purchaser of pesticides. Hence this policy option would likely not generate any additional costs, for Member States or for professional users.

In effect, it would mainly put into legislation the interpretation already made by Member States that training and certification is required for all professional users and not only the person purchasing the pesticide.

Other impacts (environmental, social, macroeconomic)

This policy option would likely not generate any additional impacts compared to the baseline situation. This was confirmed in consultations with Member States and in the targeted survey, with Member State representatives stating this measure was already in place and would thus not generate any additional impacts.

12.6.3 *Comparison of options to improve expertise of pesticide users (specific objective A4)*

Table 12-18 addressing the options to improve expertise of pesticide users (specific objective A4)

	A4.1.LE.a
Impacts	
Professional users	/
National authorities	/
European Institutions	/

[693] One Member State is currently implementing the training system, it is expected to be fully operational in 2023.

	A4.1.LE.a
Other stakeholders	/
General society (Environmental. social, macroeconomic impacts)	/
Other criteria	
Effectiveness	/ *Clarifying the current provision in the SUD; however, it was already interpreted in this way by Member States so no additional costs would occur and the situation would not change*
Coherence	*No coherence issues*
Efficiency	/
Proportionality	**+++** *Considered highly proportionate.*
Subsidiarity	No issue

/: no impact

Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)

Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)

(): brackets if costs, benefits etc. are only potentially

If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +

13. Assessment and comparison of impacts from policy options addressing data availability and monitoring

13.1 Introduction

This chapter sections assesses the direct economic costs (provisions as well as, where relevant, the environmental, social, and macroeconomic costs) from policy options to reach the objectives under the group of "strengthening data availability and monitoring". The specific objective under this group is as follows:

- **B1:** Monitor the use as well as the risk of use from pesticides and use the information for policy development at Member State and EU level

Under the specific objective, three operational objectives are defined for each of which a number of policy options for reaching those operational objectives are then assessed. Some of these are mutually exclusive while others can be combined to cumulate effects. This is further explained below.

Under each general objective, the options are ultimately compared based on their impacts, effectiveness and coherence, efficiency and proportionality as well as subsidiarity. The approach to the comparison is presented in Section 6.2.

13.2 Discarded policy options

No policy options have been discarded in this group.

13.3 Impact from policy options addressing the monitoring of use as well as the risk of use from pesticides equipment (specific objective B1)

13.3.1 Overview

The table overleaf below summarises the options for achieving this objective.

Table 13-1 Policy options for addressing the specific objective

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitions option
B1: Monitor the use as well as the risk of use from pesticides and use the information for policy development at Member State and EU level	• **B1.1:** MS make better use of available use data to allow for better monitoring	• [...]	• **B1.1.ME.a:** Oblige MS to collect in electronic manner and analyse the existing pesticide use data currently held by pesticide users under Article 67 of Reg. 1107/2009 and report on this and progress towards reaching the F2F pesticide use and risk targets to the Commission on a yearly basis as well as report at the farm level for a specific (e.g. FSDN) farms sample	• [...]
	• **B1.2:** Improve data collection on pesticide-related poisoning incidents	• **B1.2.LE.a:** Mandatory collection by MS of information on acute and chronic poisoning – delete "where available" from current SUD.	• [...]	• [...]
	• **B1.3:** Improve available information about pesticide-related health and environment risks as well as improve EU harmonised risk indicators	• **B1.3.LE.a:** MS to submit to the Commission and share information on current national health and environment monitoring indicators concerning the use and risk of pesticides as a basis for the possible future development of additional harmonised risk indicators at EU level as requested by European Court of Auditors etc.	• *Least ambitious option + the below* • **B1.3.ME.a:** Based on data collected and progress with relevant research projects such as HBM4EU, IPCHEM, LUCAS, Commission to propose in the longer term specific harmonised indicators	• [...]

13.3.2 *Impact from policy options addressing operational objective B1.1*

This section assesses the impacts from the policy options addressing the operational objective "Member States make better use of available use data to allow for better monitoring".

The following policy options are assessed:

- **Least ambitions options:**
  - n/a
- **Medium ambitious options**:
  - **B1.1.ME.a:** Oblige MS to collect in electronic manner and analyse the existing pesticide use data currently held by pesticide users under Article 67 of Reg. 1107/2009 and report on this and progress towards reaching the F2F pesticide use and risk targets to the Commission on a yearly basis as well as report at the farm level for a specific (e.g. FSDN) farms sample
- **Most ambitious options**:
  - n/a

Stakeholder views on Member States making better use of available use data to allow for better monitoring

Overall, PPP users and industry were of the majority view that, to date, the SUD has contributed to improving monitoring of pesticide use and the associated risks on human health and the environment. Despite this, there is a split view on the effectiveness of implementing such an option as presented in B1.1.ME.a. This was shown in the targeted survey where 50% of users and industry were of the view that this proposed policy element would have an impact on reducing the use and risk of chemical pesticides, while 43% of respondents disagreed[694]. By comparison, this option was seen to be potentially burdensome or costly (64% of users and industry). For environmental NGOs and civil society organisations, there was a similar view that this proposed policy element could lead to a reduction in use and risk of chemical pesticides to a major/ moderate extent (20 out of 22 respondents).

13.3.2.1 *Impacts from option B1.1.ME.a*

Direct economic impacts

Electronic record keeping for the collection of data from professional pesticide users regarding pesticide use is currently in place in six Member States, according to the targeted survey to Member State authorities. A further six Member States noted that record keeping systems are under implementation.

Evidence gathered during the evaluation of the study uncovered that under Article 67 on Regulation (EC) No 1107/2009, professional users are required to keep records, however the process is not automated, and data are not collected in electronic format in one system. Therefore, it can be the case that use data is currently being recorded at the farm level, however there is a disconnect from the farm to national level and national level to EU level.

In addition, the impact of requiring electronic record keeping would not supress the lag time between the cause and effect. Thus, unless Member States were to systematically collate spatial data on the use of pesticides, the lag time effect will persist and impact the ability for the statistics

[694] The remaining 7% answered that they do not know

to be used in a meaningful way. The following sub-sections explore the direct economic costs to specific stakeholder groups.

Professional users

In understanding the direct economic costs to professional users, it is useful to examine the impact from two processes: [1] the recording of data and [2] the transfer of data onto an electronic system. Under the first process, given that users are already required under Article 67 of Reg. 1107/2009 to record such information, the direct economic cost from the implementation of this option would be comparable.

On the transfer of data, evidence from countries which already collect use data often have in place a strong advisory service network thus reducing the time for users to upload data, as well as ensuring that the data that is uploaded is accurate. Thus, for those countries which already report the data at the national level, the direct economic impact would remain the same. However, as indicated in the targeted survey to professional users, the requirement to electronically transfer pesticide use records from professional pesticide users to Member State competent authorities overly burdensome or costly to implement was considered to be overly burdensome to a great/ moderate extent by the majority of users.

Crucially, no direct costs have been provided or are available by professional users, however, national quality reports on use data reported by Eurostat[695] provides some indicative estimates. It should be caveated that the not all countries reported information on the costs and administrative burden of reporting for users, thus Table 13-2 presents approximate estimates of the costs for users to submit use data/ take part in data collection surveys based on the average response time. The cost per hour is based on the EU average of 12 EUR per hour for an agricultural worker (see section 12.3.2 for more detail). Overall, while some Member States (BG, DK, FI) noted an increased administrative burden, the current data outlines minimal extra costs for users to provide the data to the national authorities.

Furthermore, on the assumption that most of Member States have in place a form of advisory service that could assist with reporting, it could be assumed that the costs to report the data would be low. However, if such services are not available, this could require greater time for the user to report, thus increasing the direct economic impact.

Table 13-2. Cost estimates for reporting use data across selected countries by users through surveys

Member State/ Country	Costs to users	Estimated cost per farmer
Belgium	All the costs and burdens are for administrative purpose. For the respondents (farmers), there is no burden in addition to their commitment to the FADN.	
Bulgaria	High administrative burden	
Denmark	Increased digitalization caused additional burden	
Estonia	108 minutes per respondent	1.8 hours = EUR 21.60 per user

[695] Eurostat. 2018. Pesticide use in agriculture (aei_pestuse) - National Quality Reports. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/aei_pestuse_esms.htm

Member State/ Country	Costs to users	Estimated cost per farmer
Finland	Specific cost not available. Submitting of pesticide data was an additional burden for the farmers.	
France	The burden on the respondent is approximately between 1 and 1.5 hour	Approx. EUR 12 – 18 per user
Germany	The respondents will receive representational allowances. The sum of these expenses was 134.500 € in 2018.	1310 farms sampled. Assuming 1 user per farm. Approx. EUR 102 per user compensation.
Greece	As far as the sellers are concerned, the burden was minimal since almost all the data collected are also required for issuing the relevant invoice.	
Ireland	Average respondent time is 25-30 mins	Approx. EUR 5 – 6 per user
Lithuania	In 2018, the average time spent by respondents on the filling-in of the statistical questionnaire – 2 hour 56 minutes.	Approx. EUR 36 per user
Netherlands	The survey is postal and mainly electronic and the range of detail of data collection has been further lowered in 2016 by sending the form every quarter of the year. Though not all farmers do have a computer use of paper is lowered to a minimum.	
Slovakia	Average time for filling in the reports on pesticide use by respondents vary and depends on acreage of their farms (in the interval from 50 to 5000 ha of agricultural land). Thus, it can be from couple minutes to 8 hours.	Approx. EUR 12-96 per user
United Kingdom	For burden on respondents: arable, £1,221; orchards, 2,611; soft fruit, £2,944; edible protected crops, £2,609; outdoor vegetable crops, £5,764, grassland & fodder approximately £6,000.[696]	Arable: EUR 1428 Orchards: EUR 3054 Soft fruit: EUR 3444 Edible protected crops: EUR 3052 Outdoor vegetable crops: EUR 6743 Grassland & fodder: EUR 7020

Source: Eurostat. 2018. Pesticide use in agriculture (aei_pestuse) - National Quality Reports. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/aei_pestuse_esms.htm

National Authorities

With regards to national authorities, evidence from the targeted survey was sparse with only a small number of Member States providing estimates of direct economic costs to both set up an electronic system and monitor that data that is submitted. For example, estimates on the development of an electronic system were provided in the region of 500,000 EUR by two Member States while monitoring ranged from two full time employees to a sum of 100,000 EUR. The divergence in these estimates and the lack of comparable estimates means that these figures should be treated with caution and only seen as indicative.

[696] It should be noted that it is assumed that these figures include the cost for the farmer to gather the data and report it and not the reporting cost alone.

To provide a more accurate picture, the table below provides figures from quality reports of use data submissions by Eurostat. Most of the information displays the cost of conducting data collection (most commonly through surveys), with total cost over a 5-year period being between 125,000 EUR – 209,800 EUR, thus averaging 25,000 EUR – 42,000 EUR per year.

Table 13-3. Cost estimates for reporting use data across selected countries by Member States through *surveys*

Member State/ Country	Reported costs
Austria	Costs for the five-year period: Cost for data collection: EUR 40.680 Costs of compensating the survey farms for the data transmission effort: EUR 30.960 Costs for data preparation, extrapolation, plausibility checks, reporting: EUR 138.160 Total cost: 209.800 €
Belgium	All the costs and burdens are for administrative purpose.
Estonia	The cost of a statistical work in Statistical Office was estimated at EUR 7.5 thousand both in 2020 and 2021.
Finland	The total cost of the statistics on pesticide use in agriculture (data collection, processing and dissemination) was estimated at 125,000 euros.
France	The cost of the 5 surveys carried out during the reference period is approximately 6,400,000 euros. Spread over the reference period (5 years), the preparation and follow-up of surveys by their respective managers represents 4 full-time equivalents for one survey.
Germany	50% of the yearly working time of a scientific officer: about 70.000 € 75% of the yearly working time of an assistant: about 50.000 €
Ireland	98,800 - €137,800 per survey
Latvia	Operational cost in total for the survey of 2019 was EUR 34.2 thousand, which includes cost for data collection EUR 32.8 thousand, for data processing and dissemination EUR 8.4 thousand respectively.
Netherlands	The costs of the statistic for SN are calculated on about 3 Full Time Employees each year.
Slovakia	Staff involved in pesticide use statistics (data collection, validation and processing): - cca 50 Regional Phyto inspectors - the Central Controlling and Testing Institute in Agriculture (CCTIA), - 4 experts - CCTIA/Plant Protection Department and Pesticides Registration Department, - 1 expert - Statistical Office of the SR/Cross-sectional Statistics Department.
Norway	Cost and burden: EUR 120,000 for surveys

Source: Eurostat. 2018. Pesticide use in agriculture (aei_pestuse) - National Quality Reports. [online] Available at: https://ec.europa.eu/eurostat/cache/metadata/en/aei_pestuse_esms.htm

EU Institutions

With regards to the impact on EU institutions, no quantitative assessment was possible, however on the basis of informed assumptions, the impact is foreseen to be minor. On the basis that the

EU's statistical body, Eurostat, already collates data on the use of pesticides, it is assumed that an increase in the volume of data being transferred would only lead to a minor impact.

Other impacts (environmental, social, macroeconomic)

An overarching finding from the evaluation and targeted interviews as part of this impact assessment was that identifying direct environmental, social and macroeconomic impacts from activity of record keeping if challenging and ambiguous.

With regards to environmental impacts, Member State authorities were unable to identify the environmental impacts of implementing this option. However, a small number did expect that better record keeping and transfer of data could have an indirect impact on helping to raise awareness of sustainable practices which in turn could have a positive impact on the environment.

With regards to social impacts, it was raised by Member State authorities that implementing this option could increase the pressures and stress placed upon users (primarily farmers). Thus, in this regard, the social impacts would be negative upon reporters. However, there is also the agreement that with better data there is the ability to make more informed decision making, which as a result could have positive societal benefits, particularly in improving the risks against human health.

13.3.3 Impacts from policy options addressing operational objective B1.2

This section assesses the impacts from the policy options addressing the specific objective "Improve data collection on pesticide-related poisoning incidents".

The following policy options are assessed:

- **Least ambitions options:**
  - **B1.2.LE.a:** Mandatory collection by MS of information on acute and chronic poisoning – delete "where available" from current SUD
- **Medium ambitious options**:
  - n/a
- **Most ambitious options**:
  - n/a

Stakeholder views on improving data collection on pesticide-related poisoning incidents

As described in the following section, evidence from the target survey to Member State authorities found varying degrees of implementation of monitoring systems on chronic and acute poisonings. Crucially, the collection of information on these two types of poisonings was seen to be challenging for Member States, particularly for chronic poisoning, where it can be more challenging to single pesticides as having caused chronic poisoning. This is combined with the findings that across Member States, there was no clear view of what impacts, positive or negative, would be accrued from implementing this proposed policy element.

13.3.3.1 *Impacts from option B1.2.LE.a*

Direct economic impacts

Risk monitoring systems are currently in place in 20 Member States[697], according to the targeted survey to Member State authorities. Through their systems, 17 Member States monitor acute poisoning incidents while only 7 Member States also monitor chronic poisoning.

In the targeted survey and the consultations several Member States highlight that the provisions related to health (and environmental) monitoring needs to be strongly linked to other legislation to allow for effective implementation and coordination at Member State level. Some Member States are of the opinion that risk monitoring should be dealt with either as part of Reg. 1107/2009 or in other legislation such as workers health and environmental legislation, rather than the SUD. Other Member States call for clearer guidance and a harmonised approach to risk monitoring (and exposure), to improve the evidence base on risk of pesticide use.

In conclusion, up to 10 Member States would need to take action to improve monitoring of acute poisoning from pesticides and most Member States would need to take action to monitor chronic poisoning from pesticides.

National authorities

To put in place (or improve) monitoring of acute poisoning incidents would likely only require minor investment in the Member States that current do not monitor this. Costs would be minor since the main infrastructure should be in place in all Member States, with poison centres[698] responsible for receiving information on preparations/mixtures considered dangerous/hazardous based on their health or physical effects. The additional cost would be related to ensuring that acute poisoning incidents involving pesticides are duly recorded and reported, where this is not already the case.

To monitor chronic poising from pesticides would likely require more efforts and costs. A screening of the existing systems reported from Member States reveal that most of them concern acute and not chronic poisoning. Member States were not able to provide estimations of costs for their current systems, but clearly any system that regular monitoring of potential chronic poisoning linked to exposure data would be more complex and costly to develop[699]. A harmonised approach to monitoring of exposure and chronic poisoning could potentially reduce costs for Member States and strengthen the evidence base, however this would entail costs at EU level.

Other stakeholders

This option would not entail additional costs for other stakeholders.

Other impacts (environmental, social, macroeconomic)

Professional users

[697] 3 MS respondents answered that no monitoring of acute poisoning is in place and 3 respondents answered that they did not know.

[698] (Article 45 of the EU Regulation on the classification, labelling and packaging of chemicals (CLP) (EC) No. 1272/2008)) and Article 17 of Directive 1999/45/EC (Dangerous Preparations Directive)

[699] HBM4EU which aims to coordinate biomonitoring of priority chemicals (including certain pesticides) across 26 MS has a budget of € 74 169 890 (€ 49 933 776 EU Contribution from H2020), timeline Jan 2017 to Dec 2021. The Walloon region in Belgium has initiated a biomonitoring programme to measure exposure to pesticides in the population, the estimated cost is € 5 000 000.

A stronger monitoring of acute and chronic poisoning from pesticide would generate a better evidence base for policy making. It would enable identifying and studying potential health issues and could lead to better measures and stronger protection of pesticide users and workers handling pesticides.

National Authorities

Member States would have a stronger evidence base to inform effective policies and actions to reduce the risks of pesticide use to human health.

General public

If the scope of the monitoring is expanded to the population or specific sub-groups (for example vulnerable groups such as children, pregnant women), for example through regular biomonitoring for exposure, this could generate further knowledge on the potential health effects from exposure to pesticides and help to inform future policies.

13.3.4 *Impact from policy options addressing operational objective B1.3*

This section assesses the impacts from the policy options addressing the operational objective "Improve available information about pesticide-related health and environment risks as well as improve EU harmonised risk indicators".

The following policy options are assessed:

- **Least ambitions options:**
  - **B1.3.LE.a:** MS to submit to the Commission and share information on current national health and environment monitoring indicators concerning the use and risk of pesticides as a basis for the possible future development of additional harmonised risk indicators at EU level as requested by European Court of Auditors etc.
- **Medium ambitious options**:
  - **B1.3.ME.a:** B1.3.LE.a + Based on data collected and progress with relevant research projects such as HBM4EU, IPCHEM, LUCAS, Commission to propose in the longer term specific harmonised indicators
- **Most ambitious options**:
  - n/a

Stakeholder views on improving the available information about pesticide-related health and environment risks as well as improving EU harmonised risk indicators

From the perspective of Member State authorities, there was a broad agreement that improving current indicators would help to better monitor and identify the use of and risk of chemical pesticides. Crucially, an overarching theme was for the current indicators not to be based on the sales of PPPs but rather on their use, while also taking into account environmental and social indicators, to help provide a more accurate picture of pesticide use across the EU. Generally, Member States saw opportunities for this approach and outlined a degree of willingness to work towards the sharing of information on health and environment monitoring indicators.

13.3.4.1 *Impacts from option B1.3.LE.a*

Direct economic impacts

Under Article 4 of the SUD, Member States are required to prepare NAPs which should establish quantitative objectives, targets, measures and timetables to reduce the risks and impacts of pesticide use on human health and the environment. Member States are also required to review their NAPs at least every five years.

As per an assessment done by the European Commission in 2020[700], only a few Member States had identified useful indicators on risk reduction; other indicators put forward by Member States included indicators on use reduction, and another group of indicators was based on compliance with selected provisions of the SUD (e.g. operator training).

The first NAPs had to be published by November 2012 and then to be reviewed at least every five years. At the time of the assessment by the European Commission, seven Member States had not yet completed the review of their initial NAP.

The assessment by the European Commission was preliminarily based on a review of the NAPs[701]. This policy option would require Member States to share information on current national health and environment monitoring indicators, to feed into the European Commission's efforts to revise EU-wide Harmonised Risk Indicators. In general, only little costs would arise from this policy option.

In order to maximise effectiveness of this policy option, it is likely that the European Commission would develop a template for Member States to provide information in in order to make received information useful and comparable. Developing this template would entail some minor cots for the European Commission.

The costs that Member States face depends on the details asked for in the template. Again, in order to maximise usefulness of the exercise, it can be expected that the template would require Member States to not only report on technical details of the indicators, but also to include an evaluation of the indicators (e.g. on their effectiveness, efficiency, limitations). Costs for such an evaluation as well as for reporting to the European Commission would only arise for those Member States that have indicators in place.

13.3.5 Impacts from option B1.3.ME.a

Direct economic impacts

While the European Commission faces costs for relevant research projects such as HBM4EU, IPCHEM and LUCAS, those are part of the baseline and do not occur due to this policy option. In addition to those research projects, the European Commission is also already pursuing other possibilities of future indicators.

No direct costs would thus arise from this policy option compared to the baseline. Since research and data collection are ongoing it is expected that this policy option would entail an obligation in the legal text for the Commission to submit a specific future report and proposal on this issue of new indicators. The impacts of this work introducing potential new HRIs will be assessed in the future.

[700] Report from the Commission to the European Parliament and the Council on the experience gained by Member States on the implementation of national targets established in their National Action Plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides. See: https://ec.europa.eu/food/system/files/2020-05/pesticides_sud_report-act_2020_en.pdf

[701] In addition to other information sources, such as correspondence, audit reports and others.

13.3.6 *Comparison of options addressing the monitoring of the use as well as the risk of use from pesticides and use the information for policy development at Member State and EU level (specific objective B1)*

Table 13-4 addressing the monitoring of the use as well as the risk of use from pesticides and use the information for policy development at Member State and EU level (specific objective B1)

	B1.1.ME.a	B1.2.LE.a	B1.3.LE.a	B1.3.ME.a
Impacts				
Professional users	**Recording data on pesticide use: /** *Already required under Article 67 of Reg. No. 1107/2009* **Transfer of data to public authorities: / to ---** Electronic transfer is currently not mandatory and only required in selected Member States. In other Member States electronic devices may need to be purchased and time for filling in submission tools	/	**/**	**/**
National authorities	**Develop electronic record keeping system: - to --** **Compiling national statistics and monitoring quality of input: - to --**	**Put in place or improve monitoring of acute poisoning: -** **Costs for monitoring of chronic poisoning: --** *Likely relatively high. A harmonised approach to monitoring of exposure and chronic poisoning could potentially reduce costs for Member States and strengthen the evidence base, however this would entail costs at EU level.*	**Share information on existing indicators: / to –** *Depending on the details in the template to be developed by the European Commission and the need for conducting an evaluation of existing indicators the costs for the policy option could be negligible to low. Costs would only occur for those countries that have relevant indicators in place.*	**/**

	B1.1.ME.a	B1.2.LE.a	B1.3.LE.a	B1.3.ME.a
European Institutions	**Compiling EU statistics and monitoring quality of input: - to --**	(see above)	**Develop a template/minimum requirements for sharing information: -**	**(No additional costs compared to the baseline)**
Other stakeholders	**All stakeholders and society: Improved understanding of pesticide use: +++** *Better evidence base for pest management, policymaking and public debate*	/	/	/
General society (Environmental. social, macroeconomic impacts)	*Indirect effects of better and more accurate data availability*	/	/	/
Other criteria				
Effectiveness	++ *Data on use is already recorded and could improve the monitoring of risk and use related to the specific application of pesticides*	++ *Most Member States already have monitoring of acute poisoning in place; the policy option would ensure that also the remaining countries would collect the data which could be done with very little cost.*	++	++
Coherence	*No coherence issues*	*No coherence issues*	*No coherence issues*	*No coherence issues*
Efficiency	++ *Likely upfront investments for authorities and users but relatively small additional recurring burden for individual users*	++	+++	++
Proportionality	+++ *Despite the additional butrden it is considered proportionate since*	**+ to +++** *Proportionality for actue poisoning is considered high. For*	+++	+++

	B1.1.ME.a	B1.2.LE.a	B1.3.LE.a	B1.3.ME.a
	this measure would address relevant data needs	*chronic poisoning the proportionality can be considered to be lower since the assessments would be complex and resource intensive.*		
Subsidiarity	No issues	No issues	No issues	No issues

/: no impact

Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)

Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)

(): brackets if costs, benefits etc. are only potentially

If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +

The green coloured cells pertain to the preferred option of the Commission

The blue coloured cells pertain to the option that was assessed positively from the Assessment

14. Assessment and comparison of impacts from policy options addressing new technologies

14.1 Introduction

This chapter sections assesses the direct economic costs (provisions as well as, where relevant, the environmental, social, and macroeconomic costs) from policy options to reach the objectives under the group of "Policy options accounting for new technologies". The specific objectives under this group include the following:

- **D1:** Promote precision farming and the development of alternatives to chemical pesticides through the SUD
- **D2:** Account for drones in the SUD
- **D3:** Revise SUD provisions to account for emerging technologies and techniques

Under each specific objective, different operational objectives are defined for each of which a number of policy options for reaching those operational objectives are then assessed. Some of these are mutually exclusive while others can be combined to cumulate effects. This is explained further under each specific objective.

Under each general objective, the options are ultimately compared based on their impacts, effectiveness and coherence, efficiency and proportionality as well as subsidiarity. The approach to the comparison is presented in Section 6.2.

14.2 Discarded policy options

No policy options have been discarded in this group.

14.3 Impact from policy options addressing the promotion of precision farming and the development of alternatives to chemical pesticides equipment (specific objective D1)

14.3.1 Overview

The table overleaf below summarises the options for achieving this objective.

Table 14-1 Policy options for addressing the specific objective

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitions option
D1: Promote precision farming and the development of alternatives to chemical pesticides through the SUD	• **D1.1:** Promote the development and application of precision farming • **D1.2:** Promote the development of alternative methods/products to reduce the use and risk of pesticides.	• **D1.1.LE.a:** Commission and MS to promote targeted training and advice measures for precision farming to have an efficient uptake from professional pesticide users, • **D1.2.LE.a:** Commission and MS to promote the use of forecasting tools and prediction models and the development of alternative methods that can help to reduce the use and risk of pesticides	• [...]	• [...]

14.3.2 Impact from policy options addressing operational objective D1.1

This section assesses the impacts from the policy option addressing the operational objective "Promote the development and application of precision farming".

The following policy options are assessed:

- **Least ambitions options:**
  - **D1.1.LE.a:** Commission and MS to promote targeted training and advice measures for precision farming to have an efficient uptake from professional pesticide users
- **Medium ambitious options**:
  - n/a
- **Most ambitious options**:
  - n/a

Context

Precision agriculture (PA) (also referred to as precision farming, smart farming, site-specific crop management or satellite farming) is a data-based management approach that is characterised by the collection and use of field-specific data, used to adjust the application of inputs to specific characteristics and to optimise fuel and input use (and to reduce losses that would otherwise cause pollution).

Precision farming can be based on technological spill-overs from other sectors. It can be based on different technologies and infrastructures, often involving digital solutions, such as data gathering and management systems, geographic information systems (GIS), global positioning systems (GPS), microelectronics, wireless sensor networks (WSNs), and radio frequency identification (RFID) technologies.

Put simply, precision agriculture concerns tools supporting farming decisions with a view to using the right amount of pesticide input in the right place at the right time.

Stakeholder views on the promotion of the development and application of precision farming

From the targeted survey to Member State Authorities, 14 Member States[702] answered that their country has initiatives or projects aiming to improve the uptake of technological innovations and precision/SMART farming. Of those 14 Member States, the main factors influencing uptake of new technologies were understood to be a combination of aspects including financial capacity, the varying level in knowledge and skills and general access to information and alternatives.

From the perspective of PPP users and respective industries, there is a broad agreement with the promotion of targeted training and advice measures for precision farming by the Commission and/or Member State authorities. Most notably, there is a recognition that the use of precision agriculture at scale could act as one of the most promising solutions, specifically in working towards the Commission's Farm to Fork targets. For this to be applied succinctly, there is an overall call for greater research into alternative techniques that could be used in tandem with a reduction of pesticide use.

From the environmental organisations and civil society perspective there is some acknowledgement for the use of precision farming having a role in reducing the use of pesticides, however it is seen as an action which cannot achieve positive effects when operating in isolation. Specifically, precision farming is seen to be most effective when incorporated with IPM principles and other less harmful methods, such as biocontrol measures, set aside land for biodiversity and better training for users of pesticides.

14.3.2.1 *Impacts from option D1.1.LE.a*

Direct economic impacts

Direct economic impacts will arise from the promotion activities. Therefore, costs would likely arise for the Commission and Member States for conducting the promotion activities or money spent on initiatives, whereas developers, providers and users would benefit from these activities. However, the promotion activities are not detailed at this stage which make an assessment impossible.

Several Member States have existing promotion schemes for precision farming; however, these are mainly targeted at research through funding. Four Member States[703] mention already existing demonstration projects or advisors with public support.

Depending on the selected approach and type of promotion, also the Commission would incur costs from administering the promotion programme and applying precision farming techniques – even with promotion support – will have economic impacts on pesticide users. Purchasing new equipment needed for precision farming is expensive and one of the main barriers to the uptake of such technologies[704]. Therefore, for many farmers, especially in countries with small-scale farm landscape or low incomes in agriculture, such investments will likely not be made in the short term. However, precision farming technologies aim at ensuring constant yields with a lower – because

[702] Austria, Belgium, Czechia, Denmark, Finland, Germany, Greece, Ireland, Latvia, Luxembourg, Netherlands, Poland, Spain, Sweden

[703] Belgium, Czechia, Finland, Netherlands

[704] Financial capacity is ranked the top barrier and indicated by 21 out of 36 respondents from MS authorities in the targeted survey on the question "What would be the main factors influencing uptake of new technologies in your country?"

more targeted – use of pesticides. This subsequently lowers the pesticide expense for farmers, with a cumulating economic benefit in the future.

Providers of the technologies and of training or advice benefit from the likely increase in demand for their products and services, in equal amounts as farmers invest in these items.

Other impacts (environmental, social, macroeconomic)

If the reduction of pesticide use materialises because of precision farming techniques, environmental and human health benefits, such as lower exposure of non-target species and of users or bystanders can be expected.

14.3.3 *Impact from policy options addressing operational objective D1.2*

This section assesses the impacts from the policy option addressing the operational objective "Promote the development of alternative methods/products to reduce the use and risk of pesticides".

The following policy options are assessed:

- **Least ambitions options:**
  - **D1.2.LE.a:** Commission and MS to promote the use of forecasting tools and prediction models and the development of alternative methods that can help to reduce the use and risk of pesticides
- **Medium ambitious options**:
  - n/a
- **Most ambitious options**:
  - n/a

Stakeholder views on the promotion of the development of alternative methods/products to reduce the use and risk of pesticides

Member State authorities are generally supportive of the promotion of the development of alternative methods/products to reduce the use and risk of pesticides. The most salient view in this regard pertains to need for the SUD to set provisions or more specific guidance on alternative methods/products.

From the perspective of PPP users and respective industries, there is a broad agreement with the promotion of the development of alternative methods/products to reduce the use and risk of pesticides. For the promotion of new or alternative methods, there is recognition that there needs to be more reliable data on the risk and use of pesticides in specific scenarios, so to understand where new methods could be applied efficiently. However, there is also the view that the adoption of alternative pest management solutions is not the only solution, whereby pesticides will still remain important to use in specific contexts. For this to be applied succinctly, there is an overall call for greater research into alternative techniques that could be used in tandem with a reduction of pesticide use.

Similar to the previous category, the main view for environmental organisations and civil society perspective is that alternative methods/products play a role in the reduction of the use and risk of pesticides a role, however it is seen as an action which cannot achieve positive effects when operating in isolation. Specifically, alternative methods are seen to be most effective when incorporated with IPM principles and other less harmful methods, such as biocontrol measures, set aside land for biodiversity and better training for users of pesticides.

14.3.3.1 *Impacts from option D1.2.LE.a*

Direct economic impacts

The impacts of this option are largely comparable to option D1.1.LE.a above with the only difference being that forecasting, and prediction tools are concerned instead of technologies for the precise application of pesticides.

Other impacts (environmental, social, macroeconomic)

Similarly, other impacts are comparable to those mentioned for option D1.1.LE.a above.

14.3.4 Comparison of options for promotion of precision farming and the development of alternatives to chemical pesticides through the SUD (specific objective D1)

Table 14-2 Addressing options for promotion of precision farming and the development of alternatives to chemical pesticides through the SUD (specific objective D1)

	D1.1.LE.a	**D1.2.LE.a**
Impacts		
Professional users	**Potentially costs for new equipment: (--)** **Potentially savings from application of new equipment: (+ to ++)**	**Potentially costs for using new services: (--)** **Potentially savings from using new services: (+ to ++)**
National authorities	**Resources for promotion: -** *Relatively low since many Member States already have projects in place*	**Resources for promotion: -** *Relatively low since many Member States already have projects in place*
European Institutions	**Resources for promotion: -**	**Resources for promotion: -**
Other stakeholders	**Producers of equipment: ++** *Benefits equal to the expenses from the general society*	**Providers of services of equipment: ++** *Benefits equal to the expenses from the general society*
General society (Environmental. social, macroeconomic impacts)	**Environmental and social benefits: (++)** *From better spraying equipment resulting e.g. in less spray drift and potentially also in a reduction of use of pesticides*	**Environmental and social benefits: (++)** *From better spraying equipment resulting e.g. in less spray drift and potentially also in a reduction of use of pesticides*
Other criteria		
Effectiveness	*(Not possible to judge how effective the promotion would be)*	*(Not possible to judge how effective the promotion would be)*
Coherence	*No coherence issues*	*No coherence issues*
Efficiency	*(Not possible to judge how efficient the promotion would be)*	*(Not possible to judge how efficient the promotion would be)*
Proportionality	+++	+++
Subsidiarity	No issue	No issue

/: no impact
Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)

(): brackets if costs, benefits etc. are only potentially
If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +

14.4 Impact from policy options addressing drones (specific objective D2)

14.4.1 Overview

The table overleaf below summarises the options for achieving this objective.

Table 14-3 Policy options for addressing the specific objective

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitions option
D2: Account for drones in the SUD	• **D2.1:** Clarify rules for potential aerial spraying by drones	• **D2.1.LE.a:** Clarify that definition of aerial spraying includes spraying by drones	• *Least ambitious option + the below* • **D2.1.ME.a:** Within certain parameters, to be defined in a future legislative Annex, no derogation will be required for aerial spraying by drones[705]	• **D2.1.MO.a:** Any type of **spraying** (including aerial spraying) is allowed without prohibition and without derogation if the spraying instrument is less than 2 metres from the crop being sprayed. Other parameters concerning use and risk would need to be studied and established (retain current prohibition on aerial spraying to allow for spraying by planes and helicopters subject to derogation). • **D2.1.MO.b:** The Commission could adopt a delegating act to account for future technological progress

14.4.2 Impact from policy options addressing operational objective D2.1

This section assesses the impacts from the policy option addressing the operational objective "Clarify rules for potential aerial spraying by drones".

The following policy options are assessed:

- **Least ambitions options:**
  - **D2.1.LE.a:** Clarify that definition of aerial spraying includes spraying by drones
- **Medium ambitious options**:
  - **D2.1.ME.a:** D2.1.LE.a + Within certain parameters, to be defined in a future legislative Annex, no derogation will be required for aerial spraying by drones
- **Most ambitious options**:
  - **D2.1.MO.a:** Any type of spraying (including aerial spraying) is allowed without prohibition and without derogation if the spraying instrument is less than 2 metres from the crop being sprayed. Other parameters concerning use and risk would need to be studied and

[705] This would include more detailed Commission implementing rules on derogations for aerial spraying using drones to be defined in the future. CEN standards for unmanned aerial vehicles are in development

established (retain current prohibition on aerial spraying to allow for spraying by planes and helicopters subject to derogation).

- **D2.1.MO.b:** The Commission adopts a delegating act to account for future technological progress

Context

Spraying with drones is currently considered aerial spraying, which is banned under art.9 of SUD. Derogations can be granted by Member States, where a set of necessary conditions are met (specified in the art. 9 (2).

Stakeholder views on clarifying rules for potential aerial spraying by drones

Stakeholder views on the potential benefits, risks and costs of allowing drones to apply pesticides differ, between and within stakeholder groups. Member States representatives were generally positive to including specific provisions for drones in a revised SUD, while emphasising the need for proper risk assessments and standards to ensure that use of drones does not constitute an increased risk to human health or the environment than conventional sprayers.

In the targeted survey to users mixed views were expressed, with the majority of stakeholders being supportive towards use of drones to apply pesticides, especially in hard-to-reach areas (steep slopes) and for more targeted application. Respondents from environmental organisations did not think that the use of drones could support achieving the F2F targets, rather the contrary, and highlighted the risk of using drones in terms of spray drift and exposure to bystanders.

In the Member States survey approximately half of the respondents believe that drones would be more frequently used if it was allowed without derogation, primarily by users that use conventional techniques to apply pesticides.

14.4.2.1 *Impacts from option D2.1.LE.a*

This option would mainly include a revision of the legal text to clarify that aerial spraying includes spraying by unmanned vehicles or drones, in art. 9 of Directive. Other provisions would remain the same, i.e. derogations can be granted by Member States and should only be allowed in special cases provided the necessary conditions are met.

Direct economic impacts

This is not applicable, as it is equivalent to no change scenario under current SUD. Few Member States approve derogations for aerial spraying (due to no applications). One Members State provided an estimate of resources needed for the processing of derogations, totalling 10 days FTE for the one request.

Other impacts (environmental, social, macroeconomic)

This is not applicable, as it is equivalent to no change scenario under current SUD. It can be noted that few derogations are granted for aerial spraying and no information is available on derogations concerning drones.

14.4.2.2 *Impacts from option D2.1.ME.a*

The option includes clarifying that aerial spraying includes drones, and further stipulates that parameters must be defined in future implementing rules. This option has been further refined by the European Commission, where aerial spraying by drones is permitted for trained operators under certain use and risk parameters, to be decided based on accumulating scientific evidence and in agreement with MS through possible future implementing rules.

Consequently, the option includes the presumption that future advancements in technology and scientific evidence on the advantages/disadvantages of drones to apply pesticides will be used to define the use and risk parameters.

Direct economic impacts

To define parameters under which drones may be used without derogation will require investment in research on drones for pesticide application. There are no estimations available on what the cost would be to define such parameters. It is assumed the cost would mainly be borne by the European Commission and industry (to establish standards, improve data availability and clearly demonstrate the potential reduction in risk).

National authorities

Costs for national authorities would likely be limited, compared to the current situation. In the survey to Member States respondents did not foresee major direct costs, only regular costs of administration and control of the provision.

Pesticide users

Allowing drones under certain conditions without derogation would not impose any additional costs on pesticide users. While using drones may be more expensive than conventional sprayers, it could lead to savings as pesticides could be more easily applied in hard-to-reach areas and with less labour costs involved. There is no estimation available of UAA that is steep slope or hard-to-reach areas in Member States, but crops that may be more impacted concern perennial crops and in particular vineyards and orchards, which are grown on steep slopes in primarily southern Europe.

Other impacts (environmental, social, macroeconomic)

Using drones to apply pesticide would likely mainly replace spraying with conventional or hand-held devices in hard-to-reach areas, thereby reducing exposure to the pesticide user and reduce the risk of work-related accidents. Secondly, drones could allow to apply pesticides more targeted, for example in a field or an orchard, rather than spraying a whole field and this use less pesticides.

A recent study by the OECD working group on Drones concluded that use of drones has the potential to produce benefits, but that these potential benefits cannot be realised without further improving knowledge and data on application with drones. It calls for further development of standard test protocols and teaching tools.[706]

In the stakeholder consultations with users, respondents that were positive towards the use of drones argue that this could lead to a reduction in quantity of pesticide applied through targeted and early spot treatment of pests, as well as other benefits such as less compacted soil by engines. Other stakeholders argue that allowing aerial spraying with drones may lead to an increase in spray drift, depending on what type of sprayer the drone replaces. The benefits of drones are not considered to be sufficiently evidenced, and the risk of misuse is considered high. In the survey to Member States, half of the respondents stated that risk of pesticide use would remain the same or increase if drones were allowed, whereas the other half stated that risks would decrease.

[706] State of the Knowledge Literature Review on Unmanned Aerial Spray Systems in Agriculture, OECD, 2021, pending publication.

Hence, to conclude, there may be potential benefits to human health and the environment if drones are allowed, however this will require further work to establish and define conditions for when spraying with drones could be considered without derogation.

14.4.2.3 *Impacts from option D2.1.MO .a*

Direct economic impacts

There would be no additional costs to stakeholders compared to the options previously described.

Other impacts (environmental, social, macroeconomic)

Other impacts are similar to the option previously described, if parameters concerning use and risk are studied and established as well.

14.4.2.4 *Impacts from option D2.1.MO.b*

Direct economic impacts

There would be no additional costs to stakeholders compared to the options previously described.

Other impacts (environmental, social, macroeconomic)

Other impacts are similar to the option previously described, if parameters concerning use and risk are studied and established as well.

14.4.3 Comparison of options for accounting for drones in the SUD (specific objective D2)

Table 14-4 Addressing options for accounting for drones in the SUD (specific objective D2)

	D2.1.LE.a	D2.1.ME.a	D2.1.MO.a:	D2.1.MO.b
Impacts				
Professional users	/	/	/	*Depending on future delegated act*
National authorities	/	**(/ to -)** *Possibly resources for research on the effects of drones*	*Depending on future definition of parameters*	*Depending on future delegated act*
European Institutions	/	**(/ to -)** *Possibly resources for research on the effects of drones*	**Resources to develop additional parameters: (/ to --)**	**Resources to develop delegated legislative act: (- to --)**
Other stakeholders	/	**Research institutions: (+ to ++)** *Additional demand for research* **New technologies producers: (- to --)** *Resources to establish standards, improve data availability and clearly demonstrate the potential reduction in risk*	*Depending on future definition of parameters*	*Depending on future delegated act*
General society (Environmental. social, macroeconomic impacts)	/	**(/ to ++)** *Depending on future research findings, potential for reducing exposure to the pesticide user and reduce the risk of work-related accidents and to apply pesticides more targeted*	*Depending on future definition of parameters*	*Depending on future delegated act*
Other criteria				
Effectiveness	**-** *No change to status quo*	*Accounting for drones would be achieved but assessing the*	*Depending on future definition of parameters*	*Depending on future delegated act*

	D2.1.LE.a	D2.1.ME.a	D2.1.MO.a:	D2.1.MO.b
		effectiveness is not possible as the considerations for derogations		
Coherence	*No change to status quo*	*No coherence issues expected since it is assumed that a potential legislative Annex would be designed to not lead to any negative health and environment impacts*	*Depending on future definition of parameters*	*No coherence issues*
Efficiency	**/**	*See above*	*Depending on future definition of parameters*	*Depending on future delegated act*
Proportionality	*No change to status quo*	+++	+++	+++
Subsidiarity	No issues	No issues	*Depending on future definition of parameters*	*Depending on future delegated act*

/: no impact
Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)
(): brackets if costs, benefits etc. are only potentially
If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +
The green coloured cells pertain to the preferred option of the Commission
The blue coloured cells pertain to the option that was assessed positively from the Assessment

14.5 Impact from policy options addressing emerging technologies and techniques equipment (specific objective D3)

14.5.1 Overview

The table overleaf below summarises the options for achieving this objective.

Table 14-5 Policy options for addressing the specific objective

Specific objective	Operational objective	Least ambitious option	Medium ambitious option	Most ambitions option
D3: Revise SUD provisions to account for emerging technologies and techniques	• **D3.1:** Create conditions for harmonised testing standards of new PAE technologies	• [...]	• **D3.1.ME.a:** Promote (through CEN/ISO) harmonised standards for approval of **additional PAE**, including for precision farming technologies and smart machinery including drones[707]	• [...]
	• **D3.2:** Include reference to precision farming and new technology such as drones, smart machinery and robotics in IPM principles	• **D3.2.LE.a:** Current IPM principles in annex to SUD clarified and reworded for example to fully reflect the potential of precision farming and new technology such as drones, smart machinery and robotics to reduce the use and risk of pesticides	• [...]	• [...]

14.5.2 Impact from policy options addressing operational objective D3.1

This section assesses the impacts from the policy option addressing the operational objective "Create conditions for harmonised testing standards of new PAE technologies".

The following policy options are assessed:

- **Least ambitions options:**
  - n/a
- **Medium ambitious options**:
  - **D3.1.ME.a:** Promote (through CEN/ISO) harmonised standards for approval of **additional PAE**, including for precision farming technologies and smart machinery including drones
- **Most ambitious options**:
  - n/a

[707] See also policy option "Require all new PAE to be tested and certified before being put into use to avoid that defects and problems might otherwise only be detected years subsequently" above

Stakeholder views on creating conditions for harmonised testing standards of new PAE technologies

From the perspective of Member State authorities, a similar view was presented as to previous PAE policy elements (see section 12.4.2). In particular, there was broad support for creating conditions for harmonised testing of PAE equipment, however there was a recognition that this could lead to increased financial burden on farmers in the short term. However, the long-term economic benefits of such a process would be apparent to farmers. With regards to social and environmental benefits, Member State authorities were not able to state any clear benefits that could be anticipated following implementation of this policy element. One recurring point that was raised however, with the coherence of the SUD and the Machinery Directive (2006/42/EC), whereby there is the view that increasing the testing and certification of PAE encroaches upon the provisions set in the Directive 2006/42/EC.

Similar to the previous policy elements described in the section 12.4.2, PPP users and industry and environmental NGOs largely agree that testing of PAE is an appropriate tool to aid a reduction in the risk and use of chemical pesticides. However, this position was comparatively less supported by PPP users compared to other stakeholder groups.

14.5.2.1 *Impacts from option D3.1.ME.a*

This option is linked to options under objective D.2 regarding drones specifically, but is also broader, including other emerging technologies in PAE. This may be advances in low-drift sprayers, spot-on treatments using sensors to detect pests, robot-based technologies etc. These technologies already exist and are being used in research settings and pilots, to test and evaluate the technologies. This option aims to support this development, through promoting harmonised standards for approval of new types of PAE.

Direct economic impacts

To develop harmonised standards through CEN/ISO is an industry driven process which entails costs. If the European Commission's wish to promote standards, it could carry part of the costs for the standardisation process. There would be no additional costs imposed to industry stakeholders or pesticide users from promoting harmonised standards.

Other impacts (environmental, social, macroeconomic)

If harmonised standards are developed for new PAE technologies and precision farming, this will likely have a positive impact on human health and the environment, by ensuring that new technologies do in effect lead to a risk reduction compared to conventional PAE use.

To promote new technologies could also lead to further investment in precision farming technology, which could have positive effects on the sector, in terms of growth and employment.

14.5.3 Impact from policy options addressing operational objective D3.2

This section assesses the impacts from the policy option addressing the operational objective "Include reference to precision farming and new technology such as drones, smart machinery and robotics in IPM principles".

The following policy options are assessed:

- **Least ambitions options:**
  - **D3.2.LE.a:** Current IPM principles in annex to SUD clarified and reworded for example to fully reflect the potential of precision farming and new technology such as drones, smart machinery and robotics to reduce the use and risk of pesticides
- **Medium ambitious options**:
  - n/a
- **Most ambitious options**:
  - n/a

Stakeholder views on including references to precision farming and new technology such as drones, smart machinery and robotics in IPM principles

As discussed in the previous option, there are strong divergences on the use and promotion of new technologies in the SUD, particularly for drones. Member States representatives were generally positive to including references to precision farming and new technology such as drones, smart machinery and robotics in IPM principles. In the targeted survey to users, mixed views were expressed, and the majority of stakeholders are supportive towards use of drones to apply pesticides, especially in hard-to-reach areas (steep slopes) and for more targeted applications. This was opposed by environmental organisations, however, there is a general acceptance of rewording current IPM principles, and providing better guidance on the potential for new technology, in combination with other control techniques such as biocontrol.

14.5.3.1 *Impacts from option D3.2.LE.a*

Direct economic impacts

The assessment of impacts of this policy option is similar to policy option A1.2.LE.a (see section 12.3.3.1). Thus, it is not possible to estimate direct economic impacts from this policy option since the exact revision of the IPM principles is not known to date.

The clarifications in the IPM principles concerning drones would depend on the eventually selected policy option on operational objective D2.1 (see section 14.4.2).

Precision farming, smart machinery and robotics are technologies that potentially can reduce the use and risk of pesticides, but applicability and feasibility is highly dependent on crop type and farm type. Thus, inclusion of those technology-related clarifications in the general IPM would have its limitations and would have to stay rather high-level. It can be expected that such high-level principles on a fairly technical topic would not be effective in encouraging farmers to take those technologies up.

To further operationalise this policy option and ensure its effectiveness, it could be beneficial to combine it with policy option D1.1.LE.a (see section 14.3.2.1), i.e. with the promotion or targeted training and advice measures for precision farming which would aim at further breaking down the general principles to the operational level.[708]

As an alternative link of this policy option, it could be considered to include provisions on the use of those technologies in the crop- and region specific IPM guidelines that are discussed to be developed under policy option A1.2.LE.b (see section 12.3.3.2). To this end, the European Institutions could include in the minimum quality standards provisions on precision farming, smart machinery and robotics. In it very unlikely, however, that uptake of such technologies could be

[708] Smart machinery and robotics are not included in the scope of policy option D1.1.LE.a

made obligatory since the CAPEX (and often also OPEX) is high[709] and the capacity of farmers to invest in such technologies is limited.

Member States could decide to subsidise technologies in certain use cases (e.g., if during the development of crop- and regional specific guidelines under policy option A1.2.LE.b it is proven that certain new technologies would be highly effective) in order to reduce the use of pesticides and as contribution to their efforts to reach the pesticide-related Farm to Fork targets.

Other impacts (environmental, social, macroeconomic)

It can be expected that the uptake of relevant technologies would lead to a decrease of use and risk of use of pesticides but the extent of this depends on the technologies.

14.5.4 *Comparison of options for revising SUD provisions to account for emerging technologies and techniques (specific objective D3)*

Table 14-6 Addressing options for revising SUD provisions to account for emerging technologies and techniques (specific objective D3)

	D3.1.ME.a	D3.2.LE.a
Impacts		
Professional users	**(/)** Possible costs for users depend on the type of promotion undertaken by the Commission and Member States	**Potential for saving on expenses for pesticides:** (++)
National authorities	**(/)** Possible costs for the promotion of standards	**/**
European Institutions	**(/)** Possible costs for the promotion of standards	**Resources for revision of IPM principles: -**
Other stakeholders	**Standards setting organisations: Development of standards: -**	**/**
General society (Environmental. social, macroeconomic impacts)	**(++)** From ensuring that new PAE technologies are achieving risk reductions for human exposure and spray drift to non-target areas and species	**Environmental and social benefits: (++)** *From increased uptake of IPM and decreased use and risk of us from pesticides*
Other criteria		
Effectiveness	**(+)** *Depending on the content of the standards*	**+**
Coherence	*No coherence issues*	*No coherence issues*

[709] See also footnote 704

	D3.1.ME.a	D3.2.LE.a
Efficiency	**(+)** *Since effectiveness of the option but also costs are relatively low, it can be considered efficient*	**+** *Since effectiveness of the option but also costs are relatively low, it can be considered efficient* *Standing alone, the policy option would not be proportionate to address the issues in operationalisation of the IPM principles but as part of the overall policy options in can play a role*
Proportionality	**+++**	**+++**
Subsidiarity	No issues	No issues

/: no impact
Costs, burdens, or negative performance on indicators: signalised with between 1 and 3 minus signs, between low costs or burdens (-) and high (---)
Benefits, savings and positive performance on indicators: signalised with between 1 and 3 plus signs in the same way (+; ++; or +++)
(): brackets if costs, benefits etc. are only potentially
If there is uncertainty as to the range of costs, benefits etc. a range is indicated: e.g. ++ to +++ or – to +
The green coloured cells pertain to the preferred option of the Commission
The blue coloured cells pertain to the option that was assessed positively from the Assessment

Appendix 3: BIBLIOGRAPHY

Bibliography

Aguiar, T.R., Bortolozo, F.R., Hansel, F.A., Rasera, K. and Ferreira, M.T., (2015). Riparian buffer zones as pesticide filters of no-till crops. Environmental Science and Pollution Research, 22(14), pp.10618-10626.

Alexandratos, N., Bruinsma, J., (2012). World Agriculture Towards 2030/2050: The 2012 Revision. Rome.

Anken, T. and Waldburger, T. (2020). Working Quality, Drift Potential and Homologation of Spraying Drones in Switzerland. In: Gandorfer, M., Meyer-Aurich, A., Bernhardt, H., Maidl, F. X., Fröhlich, G. and Floto, H. (Ed.), 40. GIL-Jahrestagung, Digitalisierung für Mensch, Umwelt und Tier. Bonn: Gesellschaft für Informatik e.V.. (S. 25-30)

Antonio F. Hernández et al. (2019), "Biomonitoring of Common Organophosphate Metabolites in Hair and Urine of Children from an Agricultural Community," Environment International 131, no. March: 104997, https://doi.org/10.1016/j.envint.2019.104997.

ARC2020 (2020). Effects of Coronavirus on Agricultural Production – a First Approximation

Arora, N.K., Verma, M., Prakash, J. and Mishra, J., (2016). Regulation of biopesticides: global concerns and policies. In Bioformulations: for sustainable agriculture (pp. 283-299). Springer, New Delhi.

Assefa, T.T., Meuwissen, M.P. and Lansink, A.G.O., (2017). Price risk perceptions and management strategies in selected European food supply chains: An exploratory approach. NJAS-Wageningen Journal of Life Sciences, 80, pp.15-26.

Aubert, P.M., Schwoob, M.H. and Poux, X., (2019). Agroecology and carbon neutrality in europe by 2050: what are the issues. Findings from the ten years for Agroecology (TYFA) modelling exercise. Study, (02/19).

Autio, S., (2016). Do we listen to earthworms?: Tools for evaluating the Finnish Action Plan on the sustainable use of plant protection products. Tukes Publications Series

Azandjeme, C.S., Bouchard, M., Fayomi, B., Djrolo, F., Houinato, D., Delisle, H., (2013). Growing burden of diabetes in sub-saharan Africa: contribution of pesticides? Curr. Diabetes Rev. 9 (6), 437e449. https://doi.org/10.2174/15733998113099990078

Bailey, A.P., Garforth, C.J., Angell, B., Scott, T., Beedell, J., Beechener, S. and Rana, R.B., (2006). Helping farmers adjust to policy reforms through demonstration farms: lessons from a project in England. Journal of Farm Management, 12(10), pp.613-625.

Balafoutis, A., Mylonas, N., Fountas, S., Tsitsigiannis, D., Balsari, P., Pugliese, M., Gil, E., Nuyttens, D., Polder, G., Dekeyser, D. and Freire, F., (2019). OPTIMA-OPTimised Integrated Pest MAnagement for precise detection and control of plant diseases in perennial crops and open-field vegetables. In Conference Proceedings 12th EFITA-HAICTA-WCCA congress (pp. 42-47).

Baldi, I., Jérémie, B., Chevrier, C., Coumoul, X., Elbaz, A., Goujon, S., Jouzel, J.N., Monnereau, A., Multigner, L., Salles, B. and Siroux, V., (2021). Pesticides et effets sur la santé: Nouvelles données (Doctoral dissertation, Institut national de la santé et de la recherche médicale (INSERM)).

Ballabio, C., Panagos, P., Lugato, E., Huang, J.H., Orgiazzi, A., Jones, A., Fernández-Ugalde, O., Borrelli, P., Montanarella, L. (2018). Copper distribution in European topsoils: An assessment based on LUCAS soil survey. Science of The Total Environment. 636:282-98.

Balmford, A., Amano, T., Bartlett, H., Chadwick, D., Collins, A., Edwards, D., Field, R., Garnsworthy, P., Green, R., Smith, P., Waters, H., Whitmore, A., Broom, D. M., Chara, J., Finch, T., Garnett, E., Gathorne-Hardy, A., Hernandez-Medrano, J., Herrero, M., Hua, F., Latawiec, A., Misselbrook, T., Phalan, B., Simmons, B. I., Takahashi, T., Vause, J., Ermgassen, E. and Eisner, R. (2018), 'The environmental costs and benefits of high-yield farming', Nature Sustainability 1(9): pp. 477–85.

Bareille, F. and Dupraz, P., (2020). Productive Capacity of Biodiversity: Crop Diversity and Permanent Grasslands in Northwestern France. Environmental and Resource Economics, 77(2), pp.365-399.

Bareille, F. and Gohin, A., (2020). Simulating the market and environmental impacts of French pesticide policies: A macroeconomic assessment. Annals of economics and statistics, (139), pp.1-28.

Barlow, S.M., Boobis, A.R., Bridges, J., Cockburn, A., Dekant, W., Hepburn, P., Houben, G.F., König, J., Nauta, M.J., Schuermans, J. and Bánáti, D., (2015). The role of hazard-and risk-based approaches in ensuring food safety. Trends in Food Science & Technology, 46(2), pp.176-188.

Barratt, B.I.P., Moran, V.C., Bigler, F. and Van Lenteren, J.C., (2018). The status of biological control and recommendations for improving uptake for the future. BioControl, 63(1), pp.155-167.

Barreiro Hurle, J., Bogonos, M., Himics, M., Hristov, J., Perez Dominguez, I., Sahoo, A., Salputra, G., Weiss, F., Baldoni, E. and Elleby, C., Modelling environmental and climate ambition in the agricultural sector with the CAPRI model, EUR 30317 EN, Publications Office of the European Union, Luxembourg, 2021.

Barzman, M. et.al. (2015). Eight principles of Integrated Pest Management. Agronomy for Sustainable Development, 35. Pp. 1199-1215.

Beckman, J., Ivanic, M., Jelliffe, J.L., Baquedano, F.G. and Scott, S.G., (2020). Economic and Food Security Impacts of Agricultural Input Reduction Under the European Union Green Deal's Farm to Fork and Biodiversity Strategies (No. 1473-2020-1039).

Beckman, J., Ivanic, M., Jelliffe, J., Baquedano, F.G., and Scott, S. (2020) Economic and Food Security Impacts of Agricultural Input Reduction Under the European Union Green Deal's Farm to Fork and Biodiversity Strategies, EB-30, U.S. Department of Agriculture, Economic Research Service.

Bellemare M. F., Çakir M., Peterson H. H., Novak L., Rudi J. (2017). On the Measurement of Food Waste. American Journal of Agricultural Economics, 9(5): 1148-1158.

Bengtsson JA. (2015) Biological control as an ecosystem service: partitioning contributions of nature and human inputs to yield. Ecological Entomology; 40:45-55.

Benton, T., Bieg, C., Harwatt, H., Wellesley, L. and Pudasaini, R., (2021). Food System Impacts on Biodiversity Loss Three Levers for Food Sys-tem Transformation in Support of Nature. London, UK: The Royal Institute of International Affairs, Chatham House, pp.2021-02.

BEUC (2020). One bite at a time: Consumers and the transition to sustainable food. https://www.beuc.eu/publications/beuc-x-2020-042_consumers_and_the_transition_to_sustainable_food.pdf

BiPRO (2004). Assessing economic impacts of the specific measures to be part of the Thematic Strategy on the Sustainable Use of Pesticides.

Böcker, T.G. and Finger, R., (2017). A meta-analysis on the elasticity of demand for pesticides. Journal of Agricultural Economics, 68(2), pp.518-533.

Boedeker, W., Watts, M., Clausing, P. et al. (2020). The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. BMC Public Health 20, 1875.

Bohlen PJ, Lynch S, Shabman L, Clark M, Shukla S, Swain H. Paying for environmental services from agricultural lands: an example from the northern Everglades. Frontiers in Ecology and the Environment. 2009 Feb;7(1):46-55.

Bossio D.A., Cook-Patton S.C., Ellis, P.W., Fargione, J., Sanderman J., Smith, P., Wood, S., Zomer, R.J., Von Unger M, Emmer IM, Griscom BW. (2020). The role of soil carbon in natural climate solutions. Nature Sustainability; 3(5):391-8.

Boussemart, J.P., Leleu, H. and Ojo, O., (2011). Could society's willingness to reduce pesticide use be aligned with farmers' economic self-interest?. Ecological economics, 70(10), pp.1797-1804.

Brack, W., Aissa, S.A., Backhaus, T. et al (2019). Effect-based methods are key. The European Collaborative Project SOLUTIONS recommends integrating effect-based methods for diagnosis and monitoring of water quality. Environ Sci Eur 31, 10. https://doi.org/10.1186/s12302-019-0192-2

Bremmer J, Deacon S, Alvarez L, Arts G, Huiting H, Smit B. (2020). Impact Assessment Framework with Specific Protection Goals (SPGs) for Non-Target Terrestrial Plants (NTTPs). Wageningen Economic Research.

Brittain, C.A., et al., (2010). Impacts of a pesticide on pollinator species richness at different spatial scales. Basic and Applied Ecology. 11(2): p. 106-115.

Britz W., Dudu H., Fusacchia I., Jafari Y., Roson R., Salvatici L., Sartori M. (2019). Economy-wide analysis of food waste reductions and related costs: A Global CGE analysis for the EU at NUTS-II Level.

Brühl, C.A. and Zaller, J.G., (2019). Biodiversity decline as a consequence of an inappropriate environmental risk assessment of pesticides. Frontiers in Environmental Science, p.177.

Bryan, John, (2020). Compatibility of EU trade policy with the European Green Deal. NAT/791-EESC-2020-EESC-2020-01349. Plenary session 554, Sep 16 – Sep 18, 2020. Available at: https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/compatibility-eu-trade-policy-european-green-deal-own-initiative-opinion

Bukeviciute, L., Dierx, A. and Ilzkovitz, F., (2009). The functioning of the food supply chain and its effect on food prices in the European Union (No. 47). Office for Infrastructures and Logistics of the European Communities.

Cadillo-Benalcazar, J.J., Renner, A. and Giampietro, M., (2020). A multiscale integrated analysis of the factors characterizing the sustainability of food systems in Europe. Journal of Environmental Management, 271, p.110944.

Caldier, P. and Drésin, E., (2018). European panorama of the agricultural, rural and forestry contractors. Bruselas: Ceettar

Caroline Linhart et al., (2019) "Pesticide Contamination and Associated Risk Factors at Public Playgrounds near Intensively Managed Apple and Wine Orchards," Environmental Sciences Europe 31, no. 1 (2019), https://doi.org/10.1186/s12302-019-0206-0.

Catapult Satellite Applications, (2017). Agricultural technology market review. Available at: https://sa.catapult.org.uk/wp-content/uploads/2018/12/Agri-tech-Market-Report_090617.pdf

Cerruto E., Manetto G., Longo D., Papa R. (2020) Sprayer Inspection in Sicily on the Basis of Workshop Activity. In: Coppola A., Di Renzo G., Altieri G., D'Antonio P. (eds) Innovative Biosystems Engineering for Sustainable Agriculture, Forestry and Food Production. MID-TERM AIIA 2019. Lecture Notes in Civil Engineering, vol 67. Springer, Cham. https://doi.org/10.1007/978-3-030-39299-4_52

Chandler, D., Bailey, A.S., Tatchell, G.M., Davidson, G., Greaves, J. and Grant, W.P., (2011). The development, regulation and use of biopesticides for integrated pest management. Philosophical Transactions of the Royal Society B: Biological Sciences, 366(1573), pp.1987-1998.

Chapman, P., (2014). Is the regulatory regime for the registration of plant protection products in the EU potentially compromising food security?. Food and Energy Security, 3(1), pp.1-6.

COCERAL-UNISTOCK, (2021). Impact of the Farm to Fork targets on the Cereals and Oilseeds markets. COCERA-UNISTOCK's main findings. Available at: https://nofota.com/wp-content/uploads/20210525_COCERAL-UNISTOCK_Impact_of_the_Farm_to_Fork_final_210521-1.pdf

Colbach N, Petit S, Chauvel B,Deytieux V, Lechenet M,Munier-Jolain N and Cordeau S (2020). The Pitfalls of Relating Weeds, Herbicide Use, and Crop Yield: Don't Fall into the Trap! A Critical Review. Front. Agron. 2:615470.doi: 10.3389/fagro.2020.615470

Cole LJ, Kleijn D, Dicks LV, Stout JC, Potts SG, Albrecht M, Balzan MV, Bartomeus I, Bebeli PJ, Bevk D, Biesmeijer JC. (2020). A critical analysis of the potential for EU Common Agricultural Policy measures to support wild pollinators on farmland. Journal of Applied Ecology. 57(4):681-94.

Colloff MJ, Lindsay EA, Cook DC. Natural pest control in citrus as an ecosystem service: Integrating ecology, economics and management at the farm scale. Biological control. 2013 Nov 1;67(2):170-7.

CONCORDE (2017): Produitsphytosanitairesdansl'agriculture:l'urgenced'uneapprochedépassionnée et rationnelle.Lecasduglyphosate,"Discussionpaper,FondationConcorde,France

Copa Cogeca., (2011). Implementing good practice within the Sustainable Use Directive for Plant Protection Products: the farmer's perspective

Cox, S., Niskar, A., Narayan, V., Marcus, M., (2007). Prevalence of self-reported diabetes and exposure to organochlorine pesticides among Mexican Americans:hispanic health and nutrition examination survey, 19821984. Environ. Health Perspect. 115 (12), 1747e1752. https://doi.org/10.1289/ehp.10258.

Creissen, H.E., Jones, P.J., Tranter, R.B., Girling, R.D., Jess, S., Burnett, F.J., Gaffney, M., Thorne, F.S. and Kildea, S., (2019). Measuring the unmeasurable? A method to quantify adoption of integrated pest management practices in temperate arable farming systems. Pest Management Science, 75(12), pp.3144-3152.

Damalas, C. A. and Eleftherohorinos, I. G. (2011) 'Pesticide exposure, safety issues, and risk assessment indicators', International Journal of Environmental Research and Public Health, 8(5), pp. 1402–1419. doi: 10.3390/ijerph8051402

Damalas, C.A. and Abdollahzadeh, G., (2016). Farmers' use of personal protective equipment during handling of plant protection products: determinants of implementation. Science of the Total Environment, 571, pp.730-736.

Damalas, C.A. and Koutroubas, S.D., (2017). Farmers' training on pesticide use is associated with elevated safety behavior. Toxics, 5(3), p.19.

Darmon, N., Drewnowski, A., (2015). Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis, Nutrition Reviews, Volume 73, Issue 10, October 2015, Pages 643–660, https://doi.org/10.1093/nutrit/nuv027

Darmon, N., Lacroix, A., Muller, L. et al. (2014). Food price policies improve diet quality while increasing socioeconomic inequalities in nutrition. Int J Behav Nutr Phys Act 11, 66. https://doi.org/10.1186/1479-5868-11-66

Davis, K.F., Downs, S. and Gephart, J.A., (2021). Towards food supply chain resilience to environmental shocks. Nature Food, 2(1), pp.54-65.

Deacon, S., Norman, S., Nicolette, J., Reub, G., Greene, G., Osborn, R. and Andrews, P., (2015). Integrating ecosystem services into risk management decisions: Case study with Spanish citrus and the insecticide chlorpyrifos. Science of the Total Environment, 505, pp.732-739.

DEFRA (2020). Review of Evidence on Integrated Pest Management. Final Report.

del Cerro, J., Cruz Ulloa, C., Barrientos, A. and de León Rivas, J., (2021). Unmanned aerial vehicles in agriculture: A survey. Agronomy, 11(2), p.203.

Del Cerro, J.et al. (2021), "Unmanned Aerial Vehicles in Agriculture: A Survey," Agronomy 11, no. 2 (2021), https://doi.org/10.3390/agronomy11020203.

Dereumeaux, C. et al. (2020) 'Pesticide exposures for residents living close to agricultural lands: A review', Environment International. Elsevier, 134(September 2019), p. 105210. doi: 10.1016/j.envint.2019.105210.

Dessart, F.J., Barreiro-Hurlé, J. and van Bavel, R., (2019). Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review. European Review of Agricultural Economics, 46(3), pp.417-471.

Diakosavvas, D., Psaltopoulos, D., Wesseler, J.H.H. and Skuras, D., (2016). Farm management practices to foster green growth (No. IKEEBOOK-2020-618). OECD.

Dimitrovski (2017). Inspection of pesticide application equipment. Journal of Agriculture and Plant Sciences. Volume 15. https://js.ugd.edu.mk/index.php/YFA/article/view/1915

Djaniana, M.l and Ferreria, N., (2020). Agriculture sector: Preparing for disruption in the food value chain. McKinsey

Durham, Timothy C., and Tamás Mizik. (2021). Comparative Economics of Conventional, Organic, and Alternative Agricultural Production Systems. Economies 9: 64. https://doi.org/10.3390/economies9020064

EASAC, (2018). Opportunities for soil sustainability in Europe. EASAC policy report 36 September 2018 ISBN: 978-3-8047-3898-0

Ecorys (2018). Study supporting the REFIT Evaluation of the EU legislation on plant protection products and pesticides residues (Regulation (EC) No 1107/2009 and Regulation (EC) No 396/2005).

EEA (2015). Briefing paper: Agriculture. Published 18 Feb 2015. https://www.eea.europa.eu/soer/2015/europe/agriculture

EEA (2017). Climate change impacts and vulnerability in Europe 2016 - An indicator-based report.

EEA (2018). Pesticide sales; Briefing. Published 29 Nov 2018, modified 26 Nov 2019

EEA (2020). Pesticides in European rivers, lakes and groundwaters – Data assessment. ETC/ICM Technical Report 1/2020

EEA, (2018). "European Waters. Assessment of Status and Pressures 2018. EEA Report No 7/2018,", https://www.eea.europa.eu/publications/state-of-water.

EEA, (2018). Common birds and butterflies, Briefing paper. Airs/2018/natural-capital/common-birds-and-butterflies. https://www.eea.europa.eu/airs/2017/natural-capital/common-birds-and-butterflies

EEA, (2020). "ETC/ICM Report 1/2020: Pesticides in European Rivers, Lakes and Groundwaters - Data Assessment,", https://www.eionet.europa.eu/etcs/etc-icm/products/etc-icm-report-1-2020-pesticides-in-european-rivers-lakes-and-groundwaters-data-assessment.

EESC (2018). Opinion on The Civil society's contribution to the development of a comprehensive food policy in the EU, OJ C 129, 11.04.2018, p. 18.

EESC (2020). Evaluation of the Sustainable Use of Pesticides Directive. Information report, Section for Agriculture, Rural Development and the Environment.

EFSA (2016). Guidance to develop specific protection goals options for environmental risk assessment at EFSA, in relation to biodiversity and ecosystem services. EFSA Journal. 2016 Jun;14(6):e04499.

EFSA (2020). Climate change as a driver of emerging risks for food and feed safety, plant, animal health and nutritional quality. doi:10.2903/sp.efsa.2020.EN-1881

EFSA (2020). European Union report on pesticide residues in food (2008-2019).

EFSA Panel on Plant Protection Products and their Residues. (2015). Scientific Opinion on the effect assessment for pesticides on sediment organisms in edge-of-field surface water. EFSA Journal. 2015 Jul;13(7):4176.

Elin Röös et al. (2018), "Risks and Opportunities of Increasing Yields in Organic Farming. A Review," Agronomy for Sustainable Development 2018 38:2 38, no. 2: 1–21, https://doi.org/10.1007/S13593-018-0489-3.

EPRS (2018). European Implementation Assessment

EU Agricultural Markets Brief (2015), No. 4.Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/trade/documents/agri-market-brief-04_en.pdf

EurEau, 2020. The governance of water services in Europe. 2020 edition.

Eurobarometer (2020). Special Eurobarometer 505. Making our food fit for the future – Citizens' expectations. https://europa.eu/eurobarometer/api/deliverable/download/file?deliverableId=73867

Eurobarometer (2021). Health, Sustainability and New Priorities Drive Organic Food Sales. https://blog.euromonitor.com/health-sustainability-and-new-priorities-drive-organic-food-sales/

European Commission (2000). Directive 2000/60/EC of The European Parliament and of The Council of 23 October 2000 establishing a framework for Community action in the field of water policy

European Commission (2005). Regulation (EC) No 396/2005 of The European Parliament and of The Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant

European Commission (2006). A Thematic Strategy on the Sustainable Use of Pesticides. COM(2006) 372 final

European Commission (2006). Commission staff working paper accompanying the proposal for a Directive of the European Parliament and of the Council establishing a framework for community action to achieve a sustainable use of pesticides, {COM(2006) 373 final}

European Commission (2006). Directive 2006/118/EC of The European Parliament and of The Council of 12 December 2006 on the protection of groundwater against pollution and deterioration

European Commission (2006): The Impact Assessment of the Thematic Strategy on the Sustainable Use of Pesticides. Online: https://ec.europa.eu/environment/archives/ppps/pdf/sec_2006_0894.pdf. SEC (2006) 894.

European Commission (2008). Directive 2008/105/EC of The European Parliament and of The Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council

European Commission (2008). Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

European Commission (2009) Development of guidance for establishing Integrated Pest Management (IPM) principles. Final Report. 07.0307/2008/504015/ETU/B3. Brussels.

European Commission (2009). Directive 2009/127/EC of The European Parliament and of The Council of 21 October 2009 amending Directive 2006/42/EC with regard to machinery for pesticide application

European Commission (2009). Directive 2009/128/EC of The European Parliament and of The Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides

European Commission (2009). Directive 2009/147/EC of The European Parliament and of The Council of 30 November 2009 on the conservation of wild birds

European Commission (2009). Regulation (EC) No 1107/2009 of The European Parliament and of The Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC

European Commission (2009). Regulation (EC) No 1185/2009 of The European Parliament and of The Council of 25 November 2009 concerning statistics on pesticides

European Commission (2014). Report on the establishment of a European fund for minor uses in the field of plant protection products. COM(2014) 82 final

European Commission (2015): Cost of and good practices for FADN data collection. See: https://op.europa.eu/en/publication-detail/-/publication/02ee48a9-d479-11e5-a4b5-01aa75ed71a1

European Commission (2016). Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (2016): Cumulative Cost Assessment for the EU Chemical Industry (Report). Online: https://op.europa.eu/en/publication-detail/-/publication/8eb1b47a-ee94-11e6-ad7c-01aa75ed71a1/language-en

European Commission (2016). Report on the sustainable use of biocides pursuant to Article 18 of Regulation (EU) No 528/2012 of the European Parliament and of the Council concerning the making available on the market and use of biocidal products. COM(2016) 151

European Commission (2017) Guidance on monitoring and surveying of impacts of pesticide use on human health and the environment under Article 7(3) of Directive 2009/128/EC establishing a framework for Community action to achieve the sustainable use. Brussels. Commission Notice of 10.10.2017.

European Commission (2017). Commission Staff Working Document Evaluation: Accompanying the document, Strategy for Agricultural Statistics 2020 and beyond and subsequent potential legislative scenarios

European Commission (2017). Evaluation accompanying the document Strategy for Agricultural Statistics 2020 and beyond and subsequent potential legislative scenarios. Commission Staff Working Document.

European Commission (2017). Evaluation Study of the Payment for Agricultural Practices Beneficial for the Climate and the Environment. Alliance Environment and the Thünen Institute.

European Commission (2017). Implementation of Regulation (EC) No 1185/2009 of the European Parliament and of the Council of 25 November 2009 concerning statistics on pesticides. COM(2017) 109 final

European Commission (2017). On Member State National Action Plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides

European Commission (2017). Report from the Commission to the European Parliament and the Council on the implementation of Regulation (EC) No 1185/2009 of the European Parliament and of the Council of 25 November 2009 concerning statistics on pesticides

European Commission (2017): Study on the cumulative health and environmental benefits of chemical legislation: Available at: https://op.europa.eu/en/publication-detail/-/publication/b43d720c-9db0-11e7-b92d-01aa75ed71a1/language-en

European Commission (2018). Science for Environment Policy: Flying Insects in West German Nature Reserves Suffer Decline of More Than 76% (1973–2000). European Commission DG Environment News Alert Service.

European Commission (2018): EU Pollinators Initiative. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0395&from=EN

European Commission (2019). Commission Directive (EU) 2019/782 of 15 May 2019 amending Directive 2009/128/EC of the European Parliament and of the Council as regards the establishment of harmonised risk indicators.

European Commission (2019). SWD(2019) 439 final. Fitness check of the Water Framework Directive, Groundwater Directive, Environmental Quality Standards

European Commission (2020), EU agricultural outlook for markets, income and environment, 2020-2030. European Commission, DG Agriculture and Rural Development, Brussels. Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agricultural-outlook-2020-report_en.pdf

European Commission (2020). Report from the Commission to the European Parliament and the Council on the experience gained by Member States on the implementation of national targets established in their National Action Plans and on progress in the implementation of Directive 2009/128/EC on the sustainable use of pesticides.

European Commission (2020). Report from the Commission to the European Parliament and the Council: Evaluation of Regulation (EC) No 1107/2009 on the placing of plant protection products on the market and of Regulation (EC) No 396/2005 on maximum residue levels of pesticides. SWD(2020) 87 final

European Commission (2020). Report from the Commission to the European Parliament and the Council on the experience gained by Member States on the implementation of national targets established in their National Action Plans and on progress in the implementation of Directive

2009/128/EC on the sustainable use of pesticides. COM(2020) 204 final. Online: https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_sud_report-act_2020_en.pdf

European Commission (2020). Report from the Commission to the European Parliament and the Council Evaluation of Regulation (EC) No 1107/2009 on the placing of plant protection products on the market and of Regulation (EC) No 396/2005 on maximum residue levels of pesticides. SWD(2020) 87 final

European Commission (2020): EU Biodiversity Strategy for 2030 - Bringing nature back into our lives. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0380&from=EN

European Commission (2020): EU Biodiversity Strategy for 2030 - Bringing nature back into our lives. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0380&from=EN

European Commission (2020): Farm to Fork Strategy - For a fair, healthy and environmentally friendly food system. Available at: https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf

European Commission (2021). Better Regulation Guidelines

European Commission (2021). Integrated Pest Management (IPM). Available at: https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/integrated-pest-management-ipm_en

European Commission (2021). Provisional version of the Delegated Regulation supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives C(2021) 2800/3 –

European Commission (2021). Report from The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions Progress in the implementation of the EU Pollinators Initiative COM/2021/261 final

European Commission, (2019). "The European Green Deal," European Commission, vol. COM(2019), https://doi.org/10.1017/CBO9781107415324.004.

European Commission, (2019). Cap Objective 3. Farmer position in value chains, Briefing note Available at: https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/cap-specific-objectives-brief-3-farmer-position-in-value-chains_en.pdf

European Commission, (2020). "A Farm to Fork Strategy for a Fair, Healthy and Environmentally-Friendly Food System,"

European Commission, (2021). "Action Plan for the Development of Organic Production" (European Commission, 2021), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0141R%2801%29.

European Commission, (2021). "Pathway to a Healthy Planet for All. EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'", https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0400&qid=1623311742827.

European Commission, (2021). The common agricultural policy at a glance. Available at: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en [Accessed 13 August 2021]

European Commission. (2019). The post-2020 common agricultural policy: environmental benefits and simplification

European Commission. 2021. Environment A. Evaluation of the impact of the CAP on Habitats, Landscapes, Biodiversity. Final Report. 2019 Nov.

European Court of Auditors (2017). Special Report No 21; Greening: a more complex income support scheme, not yet environmentally effective

European Court of Auditors (2020). Special report 15/2020: Protection of wild pollinators in the European Union - Commission initiatives have not borne fruit

European Court of Auditors (2020): Sustainable use of plant protection products: limited progress in measuring and reducing risks (Special Report).Online: https://www.eca.europa.eu/Lists/ECADocuments/SR20_05/SR_Pesticides_EN.pdf

European Environmental Agency (2020). Land and ecosystem accounts for Europe Towards geospatial environmental accounting.

European Parliament (2015) - Policy Department B based on data from European Commission (2015), 'Parliamentary Questions, Question for written answer to the Commission on the Food Supply Chain, E-000251/15.

European Parliament (2016). Research for agri committee - structural change in EU farming:howcan the CAP support a21st century European model of agriculture?. See: https://www.europarl.europa.eu/RegData/etudes/STUD/2016/573428/IPOL_STU(2016)573428_EN.pdf

European Parliament (2016). Short food supply chains and local food systems in the EU. https://www.europarl.europa.eu/RegData/etudes/BRIE/2016/586650/EPRS_BRI(2016)586650_EN.pdf

European Parliament (N.D.) Committee on Agriculture and Rural Development. Contribution in view of the public consultation on the Guidelines on the application of the specific rules set out in Articles 169, 170 and 171 of the CMO Regulation for the olive oil, beef and veal and arable crop sectors. Available at: https://ec.europa.eu/competition/consultations/2015_cmo_regulation/ep_agri_committee_annex_en.pdf

European Parliament Research Service. (2021). Statistics on agricultural inputs and outputs (SAIO): Updated rules. February 2021. https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/662607/EPRS_BRI(2021)662607_EN.pdf

European Parliament, (2016). "Precision Agriculture and the Future of Farming in Europe Scientific Foresight Study," https://doi.org/10.2861/020809.

European Parliament, (2017). "EU Policy and Legislation on Pesticides (Plant Protection Products and Biocides)," 2017, https://www.europarl.europa.eu/RegData/etudes/IDAN/2017/599428/EPRS_IDA(2017)599428_EN.pdf;

European Parliamentary Research Service (2018).Directive 2009/128/EC on the sustainable use of pesticides; European Implementation Assessment. Edited by M. Remáč. Brussels, Belgium: Ex-Post Evaluation Unit.

European Parliamentary Research Service (2019).Panel for the Future of Science and Technology; Farming without plant protection products - Can we grow without using herbicides, fungicides and insecticides? See: https://op.europa.eu/en/publication-detail/-/publication/793709ec-8e62-11e9-9369-01aa75ed71a1/language-en

European Parliamentary Research Service (2020). Panel for the Future of Science and Technology. The future of crop protection in Europe. Study. See: https://www.europarl.europa.eu/stoa/en/document/EPRS_STU(2021)656330

Eurostat (2016). Farms and farmland in the European Union – statistics. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics

Eurostat (2019). Research paper; Statistics on agricultural use of pesticides in the European Union

Eurostat (2021). Organic farming statistics. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Organic_farming_statistics

Evangelou, E., Ntritsos, G., Chondrogiorgi, M., Kavvoura, F.K., Hernandez, A.F., Ntzani, E.E., Tzoulaki, I., (2016). Exposure to pesticides and diabetes: a systematic review and meta-analysis. Environ. Int. 91, 60e68. https://doi.org/10.1016/j.envint.2016.02.013.

FAO, IFAD, UNICEF, WFP and WHO (SOFI). (2021). The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome, FAO. https://books.google.co.uk/books?hl=en&lr=&id=09zyDwAAQBAJ&oi=fnd&pg=PR1&dq=The+State+of+Food+Security+and+Nutrition+in+the+World+2021.+Transforming+food+systems+for+food+security,+improved+nutrition+and+affordable+healthy+diets+for+all&ots=WLeh7ony6t&sig=72TEK6W-xbmvoGH24pPxXkagWQQ&redir_esc=y#v=onepage&q&f=false

Ferrari, E., Chatzopoulos, T., Dominguez, I.P., Boulanger, P., Boysen-Urban, K., Himics, M. and Mâ, R., (2021). Cumulative economic impact of trade agreements on EU agriculture: 2021 update (No. JRC123037). Joint Research Centre (Seville site).

FiBL. (2021). The World of Organic Agriculture 2021. Available at: https://www.organic-world.net/yearbook/yearbook-2021/pdf.html

Flechel, A., Jolivet, A., Boukhari, R., Misslin-Tritsch, C., Manca, M.F., Wiel, E., Megarbane, B. and Pousset, F., (2018). Paraquat poisoning in Western French Guyana: A public health problem persisting ten years after its withdrawal from the French market. Eur Rev Med Pharmacol Sci, 22(20), pp.7034-7038.

Folnović, T. (2021). Best Practices for Pest Management in Organic Farm Production. Available at: https://blog.agrivi.com/post/best-practices-for-pest-management-in-organic-farm-production

Fontagné, L., Orefice, G., Piermartini, R., Rocha, N., (2015). Product standards and margins of trade: firm-level evidence. J. Int. Econ. 97 (1), 29–44.

Food and Agriculture Organization (2007). The State of Food and Agriculture. Paying Farmers for Environmental Services

Food and Agriculture Organization Corporate Statistical Database (FAOSTAT), (2021). Pesticides Use. Available at: http://www.fao.org/faostat/en/#data/RP/visualize

Forward Fooding, (2020). Looking forward at Foodtech 2020 & beyond. Foodtech data navigator.

French Ministry of sustainable development (2011). Coûts des principales pollutions agricoles de l'eau, Études & documents, Commissariat Général Au Développement Durable n° 52

Frische, T., Egerer, S., Matezki, S., Pickl, C. and Wogram, J., (2018). 5-Point programme for sustainable plant protection. Environmental Sciences Europe, 30(1), pp.1-17.

Froidevaux, J. S. P., Louboutin, B. and Jones, G. (2017) 'Does organic farming enhance biodiversity in Mediterranean vineyards? A case study with bats and arachnids', Agriculture, Ecosystems and Environment. Elsevier, 249(August), pp. 112–122. doi: 10.1016/j.agee.2017.08.012.

Gabriel, D., et al., Scale matters: the impact of organic farming on biodiversity at different spatial scales. Ecology Letters, 2010. 13(7): p. 858-869.

Gabriel, D., Sait, S. M., Kunin, W. E. and Benton, T. G. (2013), 'Food production vs. biodiversity: comparing organic and conventional agriculture', Journal of applied ecology, 50(2): pp. 355–64.

Gagic V, Kleijn D, Báldi A, Boros G, Jørgensen HB, Elek Z, Garratt MP, de Groot GA, Hedlund K, Kovács-Hostyánszki A, Marini L., (2017). Combined effects of agrochemicals and ecosystem services on crop yield across Europe. Ecology Letters. Nov;20(11):1427-36.

Galea, K. S. et al. (2015) 'Urinary biomarker concentrations of captan, chlormequat, chlorpyrifos and cypermethrin in UK adults and children living near agricultural land', Journal of Exposure Science and Environmental Epidemiology. Nature Publishing Group, 25(6), pp. 623–631. doi: 10.1038/jes.2015.54

Gallai N, Vaissière B. (2009). Guidelines for the economic valuation of pollination services at a national scale. Rome, FAO

Garibaldi, L.A., Carvalheiro, L.G., Vaissière, B.E., Gemmill-Herren, B., Hipólito, J., Freitas, B.M., Ngo, H.T., Azzu, N., Sáez, A., Åström, J. and An, J., 2016. Mutually beneficial pollinator diversity and crop yield outcomes in small and large farms. Science, 351(6271), pp.388-391. https://rid.unrn.edu.ar/bitstream/20.500.12049/3987/1/Garibaldi%20(2016)%20Mutually%20beneficial%20pollinator%20diversity%20and%20crop%20yield%20outcomes%20in%20small%20and%20large%20farms.pdf

Garrido, P. et al. (2019) 'Experimental rewilding enhances grassland functional composition and pollinator habitat use', Journal of Applied Ecology, 56(4), pp. 946–955. doi: 10.1111/1365-2664.13338

Garrido, P., Mårell, A., Öckinger, E., Skarin, A., Jansson, A. and Thulin, C.G., (2019). Experimental rewilding enhances grassland functional composition and pollinator habitat use. Journal of Applied Ecology, 56(4), pp.946-955.

Garske, B.; Bau, A.; Ekardt,F. Digitalization and AI in European Agriculture: A Strategy for Achieving Climate and Biodiversity Targets?Sustainability2021,13, 4652. https://doi.org/10.3390/su13094652

Gary D. Powney et al.,(2019). "Widespread Losses of Pollinating Insects in Britain," Nature Communications 10, no. 1: 1–6, https://doi.org/10.1038/s41467-019-08974-9;

Geissen V, Silva V, Lwanga EH, Beriot N, Oostindie K, Bin Z, Pyne E, Busink S, Zomer P, Mol H, Ritsema CJ. (2021). Cocktails of pesticide residues in conventional and organic farming systems in Europe–Legacy of the past and turning point for the future. Environmental Pollution. 2021 Jun 1;278:116827.

Geyik, O., Hadjikakou, M., Karapinar, B. and Bryan, B.A., 2021. Does global food trade close the dietary nutrient gap for the world's poorest nations?. Global Food Security, 28, p.100490.

Gilden, R.C., Huffling, K. and Sattler, B., (2010). Pesticides and health risks. Journal of Obstetric, Gynecologic & Neonatal Nursing, 39(1), pp.103-110.

Gillezeau, C., van Gerwen, M., Shaffer, R.M., Rana, I., Zhang, L., Sheppard, L. and Taioli, E., (2019). The evidence of human exposure to glyphosate: a review. Environmental Health, 18(1), pp.1-14.

Gitz V, Meybeck A, Lipper L, Young CD, Braatz S. (2016). Climate change and food security: risks and responses. Food and Agriculture Organization of the United Nations (FAO) Report. 2016;110.

Giusti, A., Pirard, C., Charlier, C., Petit, J.C., Crevecoeur, S. and Remy, S., (2018). Selection and ranking method for currently used pesticides (CUPs) monitoring in ambient air. Air Quality, Atmosphere & Health, 11(4), pp.385-396.

Gross, J. and Gündermann, G., (2016). Principles of IPM in cultivated crops and implementation of innovative strategies for sustainable plant protection. In Advances in insect control and resistance management (pp. 9-26). Springer, Cham.

Guyomard H, Bureau JC, Chatellier V, Détang-Dessendre C, Dupraz P, Jacquet F, Reboud X, Réquillart V, Soler LG, Tysebaert M. (2021). European Parliament - The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU’s natural resources.

Guyomard, H., Bureau J.-C. et al. (2020), Research for AGRI Committee – The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU’s natural resources. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

Guyomard, H., Bureau J.-C. et al. (2020), Research for AGRI Committee – The Green Deal and the CAP: policy implications to adapt farming practices and to preserve the EU’s natural resources. European Parliament, Policy Department for Structural and Cohesion Policies, Brussels.

Hackett, M. and Lawrence, A., (2014). Multifunctional role of field margins in arable farming. CEA report. Cambridge Environmental Assessments.

Haddaway, N.R., Brown, C., Eggers, S., Josefsson, J., Kronvang, B., Randall, N. and Uusi-Kämppä, J., (2016). The multifunctional roles of vegetated strips around and within agricultural fields. A systematic map protocol. Environmental Evidence, 5(1), pp.1-11.

Halada, L., Evans, D., Romao, C. and Petersen, J.-E. (2011). Which habitats of European importance depend on agricultural practices? Biodivers. Conserv. 20:2365–2378.

Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, Stenmans W, Müller A, Sumser H, Hörren T, Goulson D. (2014). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE12 (10): e0185809.

Hallmann, C. et al. (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE. 12:e0185809. doi: 10.1371/journal.pone.0185809

Hamlyn, O., (2015). Sustainability and the failure of ambition in European pesticides regulation. Journal of Environmental Law, 27(3), pp.405-429.

Handford, C.E., Elliott, C.T. and Campbell, K., (2015). A review of the global pesticide legislation and the scale of challenge in reaching the global harmonization of food safety standards. Integrated environmental assessment and management, 11(4), pp.525-536.

HBM4EU (2020). Prioritised substance group: Pesticides. https://www.hbm4eu.eu/wp-content/uploads/2021/02/HBM4EU_AD5.4_Reporting_first_and_second_set_substances_v1.1-1-Pesticides.pdf

HBM4EU (2020). Prioritised substance group: Pesticides. https://www.hbm4eu.eu/wp-content/uploads/2021/02/HBM4EU_AD5.4_Reporting_first_and_second_set_substances_v1.1-1-Pesticides.pdf

Hernandez, A.F., Lozano-Paniagua, D., Gonzalez-Alzaga, B., Kavvalakis, M.P., Tzatzarakis, M.N., Lopez-Flores, I., Aguilar-Garduno, C., Caparros-Gonzalez, R.A., Tsatsakis, A.M. and Lacasana, M., (2019). Biomonitoring of common organophosphate metabolites in hair and urine of children from an agricultural community. Environment international, 131, p.104997.

Hernandez, M.A., Ibarra, R. and Trupkin, D.R., (2014). How far do shocks move across borders? Examining volatility transmission in major agricultural futures markets. European Review of Agricultural Economics, 41(2), pp.301-325.

Hintze S, Glauser G, Hunkeler D. Influence of surface water–groundwater interactions on the spatial distribution of pesticide metabolites in groundwater. Science of The Total Environment. 2020 Sep 1;733.

HLPE. 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

Höhler, J. and Lansink, A.O., 2021. Measuring the impact of COVID-19 on stock prices and profits in the food supply chain. Agribusiness, 37(1), pp.171-186.

Holden J, Grayson RP, Berdeni D, Bird S, Chapman PJ, Edmondson JL, Firbank LG, Helgason T, Hodson ME, Hunt SF, Jones DT. The role of hedgerows in soil functioning within agricultural landscapes. Agriculture, Ecosystems & Environment. 2019 Mar 1;273:1-2.

Holzschuh Potts S., Biesmeijer K., Bommarco R., Breeze T., Carvalheiro L., Franzén M., González-Varo J.P. et al. (2015), STATUS and TRENDS of EUROPEAN POLLINATORS, ed. STEP Project (Sofia: Pensoft Publishers), https://www.researchgate.net/publication/272019008_Status_and_trends_of_European_pollinators_Key_findings_of_the_STEP_project.

Hossard, L., Archer, D.W., Bertrand, M., Colnenne-David, C., Debaeke, P., Ernfors, M., Jeuffroy, M.H., Munier-Jolain, N., Nilsson, C., Sanford, G.R. and Snapp, S.S., (2016). A Meta-Analysis of Maize and Wheat Yields in Low-Input vs. Conventional and Organic Systems. Agronomy Journal, 108(3), pp.1155-1167.

Hristov, J., Toreti, A., Pérez, I., Domínguez, F. D., Fellmann, T., Elleby, C., ... and Bratu, M. (2020). Analysis of climate change impacts on EU agriculture by 2050. Publications Office of the European Union, Luxembourg, doi, 10, 121115.

Hvězdová, M., Kosubová, P., Košíková, M., Scherr, K.E., Šimek, Z., Brodský, L., Šudoma, M., Škulcová, L., Sáňka, M., Svobodová, M. and Krkošková, L., (2018). Currently and recently used pesticides in Central European arable soils. Science of the Total Environment, 613, pp.361-370.

IEEP (2021). Biocontrol can offer a systemic and balanced solution for sustainable agriculture

IEEP (2021). What green ambitions of the CAP reform can still be salvaged?, Briefing note on the Common Agricultural Policy trilogue negotiations. Briefing note

Inserm, "Pesticides et Effets Sur La Santé : Nouvelles Données. Collection Expertise Collective." (Montrouge: EDP Sciences, 2021), https://www.inserm.fr/wp-content/uploads/2021-07/inserm-expertisecollective-pesticides2021-rapportcomplet-0.pdf.

IPBES (2021). IPBES-IPCC Co-Sponsored Workshop Report on Biodiversity and Climate Change, Online Event. Available at:https://ipbes.net/events/launch-ipbes-ipcc-co-sponsored-workshop-report-biodiversity-and-climate-change

IPPC Secretariat. (2021). Scientific review of the impact of climate change on plant pests – A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems. Rome. FAO on behalf of the IPPC Secretariat.

Jacobs C, Berglund M, Kurnik B, Dworak T, Marras S, Mereu V, Michetti M. (2019). Climate change adaptation in the agriculture sector in Europe. European Environment Agency (EEA).

Jacquet, F., Butault, J.P. and Guichard, L., (2011). An economic analysis of the possibility of reducing pesticides in French field crops. Ecological economics, 70(9), pp.1638-1648.

Jaime del Cerro et al. (2021). "Unmanned Aerial Vehicles in Agriculture: A Survey," Agronomy 11, no. 2, https://doi.org/10.3390/agronomy11020203;

James WP Nelson M Ralph Aet al. (1997). Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. BMJ. 1997;314:1545–1549.

Jay Ram Lamichhane, (2017). "Pesticide Use and Risk Reduction in European Farming Systems with IPM: An Introduction to the Special Issue," Crop Protection 97: 1–6, https://doi.org/10.1016/J.CROPRO.2017.01.017;

Jespersen, L.M., Baggesen, D.L., Fog, E. et al. (2017). Contribution of organic farming to public goods in Denmark. Org. Agr. 7, 243–266. https://doi.org/10.1007/s13165-017-0193-7

Joachim Maes et al., (2020). "Mapping and Assessment of Ecosystems and Their Services : An EU Wide Ecosystem Assessment in Support of the EU Biodiversity Strategy." Luxembourg: Publications Office of the European Union, https://doi.org/10.2760/757183.

JRC, (2015). Soil threats in Europe, technical report. Status, methods, drivers and effects on ecosystem services

Kastner, T., Erb, K.H. and Haberl, H., 2014. Rapid growth in agricultural trade: effects on global area efficiency and the role of management. Environmental Research Letters, 9(3), p.034015.

Kim, K.-H., Kabir, E. and Jahan, S. A. (2017) 'Exposure to pesticides and the associated human health effects', Science of The Total Environment, 575, pp. 525–535. doi: 10.1016/j.scitotenv.2016.09.009.

Knauer, K., (2016). Pesticides in surface waters: a comparison with regulatory acceptable concentrations (RACs) determined in the authorization process and consideration for regulation. Environmental Sciences Europe, 28(1).

Kortenkamp A. Ten years of mixing cocktails: a review of combination effects of endocrine-disrupting chemicals. Environ Health Perspect (2007) 115:98–105.10.1289/ehp.9357

Kotal F, Kožíšek F, Jeligová H, Vavrouš A, Mayerová L, Gari DW, Moulisová A. Monitoring of pesticides in drinking water: finding the right balance between under-and over-monitoring–experience from the Czech Republic. Environmental Science: Processes & Impacts. 2021;23(2):311-22.

Kristensen P, Whalley C, Zal FN, Christiansen T. European waters assessment of status and pressures 2018. EEA Report. 2018(7/2018).

Lamichhane et al. (2018) A call for stakeholders to boost integrated pest management in Europe: a vision based on the three-year European research area network project, International Journal of Pest Management, 64:4, 352-358, DOI: 10.1080/09670874.2018.1435924

Landis DA. Designing agricultural landscapes for biodiversity-based ecosystem services. Basic and Applied Ecology. 2017 Feb 1;18:1-2.

Lechenet M, Bretagnolle V, Bockstaller C, Boissinot F, Petit M-S, et al. (2014) Reconciling Pesticide Reduction with Economic and Environmental Sustainability in Arable Farming. PLoS ONE 9(6): e97922. doi:10.1371/journal.pone.0097922

Lechenet, M., Dessaint, F., Py, G., Makowski, D. and Munier-Jolain, N., (2017). Reducing pesticide use while preserving crop productivity and profitability on arable farms. Nature Plants, 3(3), pp.1-6.

Lennon RJ, Isaac NJB, Shore RF, Peach WJ, Dunn JC, Pereira MG, et al. (2019) Using long-term datasets to assess the impacts of dietary exposure to neonicotinoids on farmland bird populations in England. PLoS ONE 14(10): e0223093.

Letourneau, D. K., Salguero, B., and Montoya-Lerma, J. (2011). Does plant diversity benefit agroecosystems? A synthetic review Mathematical models and methods for surveillance and control of dengue fever View project. May 2014, 2019. https://doi.org/10.2307/29779633

Lipper L, Sakuyama T, Stringer R, Zilberman D, editors. (2009). Payment for environmental services in agricultural landscapes: Economic policies and poverty reduction in developing countries. Springer Science & Business Media; 2009 Mar 21.

Loiseleur, O., (2017). Natural products in the discovery of agrochemicals. CHIMIA International Journal for Chemistry, 71(12), pp.810-822. https://www.ingentaconnect.com/contentone/scs/chimia/2017/00000071/00000012/art00003?crawler=true&mimetype=application/pdf

Luca, C., Russo, C. and Alessandro, S., (2018). Market power and bargaining power in the EU food supply chain: the role of Producer Organizations. New Medit: Mediterranean Journal of Economics, Agriculture and Environment= Revue Méditerranéenne d'Economie Agriculture et Environment, 17(4).

Maes, J., et.al. (2020). Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN, Publications Office of the European Union, Ispra , ISBN 978-92-76-17833- 0, doi:10.2760/757183, JRC120383.

Maltby L, Brown AR, Faber JH, Galic N, Van den Brink PJ, Warwick O, Marshall S (2021) Assessing chemical risk within an ecosystem services framework: Implementation and added value Science of the Total Environment

Maroni M., Fait A., Colosio C. (1999) Risk assessment and management of occupational exposure to pesticides. Toxicol. Lett.107:145–153. doi: 10.1016/S0378-4274(99)00041-7.

Martin Lechenet et al., (2017). "Reducing Pesticide Use While Preserving Crop Productivity and Profitability on Arable Farms," Nature Plants 3, no. 3: 17008, https://doi.org/10.1038/nplants.2017.8.

McKinsey (2020). Agriculture and climate change; Reducing emissions through improved farming practices

Montanarella, L. and Panagos, P., (2021). The relevance of sustainable soil management within the European Green Deal. Land Use Policy, 100, p.104950.

Nabeshima, K. and Obashi, A., (2021). Impact of Regulatory Burdens on International Trade. Journal of the Japanese and International Economies, 59, p.101120.

Nabeshima, K., Obashi, A. and Kim, K., (2021). Impacts of additional compliance requirements of regulations on the margins of trade. Japan and the World Economy, 59, p.101088.

National Research Council (US) Committee on Copper in Drinking Water. (2000). Copper in Drinking Water. Washington (DC): National Academies Press (US); 2000. 5, Health Effects of Excess Copper. Available from: https://www.ncbi.nlm.nih.gov/books/NBK225400/

Nicholson, C. and Young, B., (2012). The relationship between supermarkets and suppliers: What are the implications for consumers. Consumers International, 1, pp.7-8.

Nicolopoulou-Stamati, P. et al. (2016) 'Chemical Pesticides and Human Health: The Urgent Need for a New Concept in Agriculture', Frontiers in Public Health, 4(July), pp. 1–8. doi: 10.3389/fpubh.2016.00148;

Nödler K, Licha T, Voutsa D. Twenty years later–atrazine concentrations in selected coastal waters of the Mediterranean and the Baltic Sea. Marine pollution bulletin. 2013 May 15;70(1-2):112-8.

Norton, L., Johnson, P., Joys, A., Stuart, R., Chamberlain, D., Feber, R., Firbank, L., Manley, W., Wolfe, M., Hart, B. and Mathews, F., (2009). Consequences of organic and non-organic farming practices for field, farm and landscape complexity. Agriculture, Ecosystems & Environment, 129(1-3), pp.221-227.

OECD (2020). COVID-19 and the Food and Agriculture Sector: Issues and Policy Responses.

OECD (2020). Managing the Biodiversity Impacts of Fertiliser and Pesticide Use. https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2020)2&docLanguage=En.

Official Journal of the European Union (2016). Interinstitutional Agreement between the European Parliament, the Council of the European Union and the European Commission on Better Law-Making.

Parfitt J., Barthel M., Macnaughton S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. Philosophical Transactions of the Royal Society B, Biological Sciences, 365: 3065-3081.

Patel S. and Sangeeta S., (2019). "Pesticides as the Drivers of Neuropsychotic Diseases, Cancers, and Teratogenicity among Agro-Workers as Well as General Public," Environmental Science and Pollution Research International 26, no. 1 (January 1, 2019): 91–100, https://doi.org/10.1007/S11356-018-3642-2.

Pedersen AB, Nielsen HØ, Christensen T, Hasler B. (2012). Optimising the effect of policy instruments: a study of farmers' decision rationales and how they match the incentives in Danish pesticide policy. Journal of Environmental Planning and Management. 2012 Oct 1;55(8):1094-110.

Phillips, M.W.A., (2020). Agrochemical industry development, trends in R&D and the impact of regulation. Pest management science, 76(10), pp.3348-3356.

Pimentel, D., McLaughlin, L., Zepp, A., Lakitan, B., Kraus, T., Kleinman, P., Vancini, F., Roach, W.J., Graap, E., Keeton, W.S. and Selig, G., (1993). Environmental and economic effects of reducing pesticide use in agriculture. Agriculture, Ecosystems & Environment, 46(1-4), pp.273-288.

Porfirio, L.L., Newth, D., Finnigan, J.J. and Cai, Y., (2018). Economic shifts in agricultural production and trade due to climate change. Palgrave Communications, 4(1), pp.1-9.

Posthuma L, Brack W, van Gils J, Focks A, Müller C, de Zwart D, Birk S. Mixtures of chemicals are important drivers of impacts on ecological status in European surface waters. Environmental Sciences Europe. 2019 Dec;31(1):1-7.

Posthuma L, Dyer SD, de Zwart D, Kapo K, Holmes CM, Burton Jr GA. (2016). Eco-epidemiology of aquatic ecosystems: Separating chemicals from multiple stressors. Science of the Total Environment. 573:1303-19.

Potts SG, Imperatriz-Fonseca V, Ngo HT, Biesmeijer JC, Breeze TD, Dicks LV, Garibaldi LA, Hill R, Settele J, Vanbergen AJ. (2016). The assessment report on pollinators, pollination and food production: summary for policymakers. Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; 2016.

Powney, G.D., Carvell, C., Edwards, M. et al. (2019). Widespread losses of pollinating insects in Britain. Nat Commun 10, 1018. https://doi.org/10.1038/s41467-019-08974-9

Rabobank, (2011). Rethinking The Food and Agribusiness Supply Chain; Impact of Agricultural Price Volatility on Sourcing Strategies.

Rani, L., Thapa, K., Kanojia, N., Sharma, N., Singh, S., Singh Grewal, A., Lal Srivastav, A., Kaushal, J. (2021). An extensive review on the consequences of chemical pesticides on human health and environment. Journal of Cleaner Production. 283: 124657. https://doi.org/10.1016/j.jclepro.2020.124657

Raphaël Charles et al., (2020). "Organic Rapeseed in Switzerland: 20 Years of Practice," 68, https://doi.org/10.1051/OCL/2020055.

Rasmussen JJ, Wiberg-Larsen P, Baattrup-Pedersen A, Bruus M, Strandberg B, Soerensen PB, Strandberg MT. (2018). Identifying potential gaps in pesticide risk assessment: Terrestrial life stages of freshwater insects. Journal of applied ecology. 55(3):1510-5.

Rega C, Bartual AM, Bocci G, Sutter L, Albrecht M, Moonen AC, Jeanneret P, van der Werf W, Pfister SC, Holland JM, Paracchini ML. (2018). A pan-European model of landscape potential to support natural pest control services. Ecological Indicators.90:653-64.

Reiler E, Jørs E, Bælum J, Huici O, Alvarez Caero MM, Cedergreen N. (2015). The influence of tomato processing on residues of organochlorine and organophosphate insecticides and their associated dietary risk. Sci Total Environ 527–528:262–9.10.1016/j.scitotenv.2015.04.081

Renner, A., Cadillo-Benalcazar, J.J., Benini, L. and Giampietro, M., (2020). Environmental pressure of the European agricultural system: Anticipating the biophysical consequences of internalization. Ecosystem Services, 46, p.101195.

Richard et al., (2020) (unpublished). Findings and limitations of the USDA-ERS study, Economic and Food Security Impacts of Agricultural Input Reduction under the European Union Green Deal's Farm to Fork and Biodiversity Strategies. Available at: https://www.inrae.fr/sites/default/files/pdf/Article%20sur%20rapport%20USDA-ERS-GB_AT_14122020_cy.pdf

Riedo J, Wettstein FE, Rösch A, Herzog C, Banerjee S, Büchi L, Charles R, Wächter D, Martin-Laurent F, Bucheli TD, Walder F. (2021). Widespread occurrence of pesticides in organically managed agricultural soils—the ghost of a conventional agricultural past?. Environmental Science & Technology. 55(5):2919-28.

Roche Ramo Jose Manuel, (2021). Evaluation on Directive on the Sustainable use of Pesticides (Information Report), Plenary session 560, Apr 27 – Apr 28 2021. Available at: https://www.eesc.europa.eu/en/our-work/opinions-information-reports/information-reports/evaluation-directive-sustainable-use-pesticides-information-report

Roux, N., Kastner, T., Erb, K.H. and Haberl, H., (2021). Does agricultural trade reduce pressure on land ecosystems? Decomposing drivers of the embodied human appropriation of net primary production. Ecological Economics, 181, p.106915.

Rust, N.A., Ridding, L., Ward, C., Clark, B., Kehoe, L., Dora, M., Whittingham, M.J., McGowan, P., Chaudhary, A., Reynolds, C.J. and Trivedy, C., (2020). How to transition to reduced-meat diets that benefit people and the planet. Science of the Total Environment, 718, p.137208.

Rutten M., Nowicki P., Bogaardt M.J., Aramyan L. (2013). Reducing Food Waste by Household and in Retail in the EU: A Prioritisation Using Economic, Land Use and Food Security Impacts. LEI report 2013-035, 156 p.

Ryberg MW, Rosenbaum RK, Mosqueron L, Fantke P. (2018). Addressing bystander exposure to agricultural pesticides in life cycle impact assessment. Chemosphere. Apr;197:541-549. doi: 10.1016/j.chemosphere.2018.01.088. PMID: 29407816.

Sanchez B, Barreiro-Hurle J, Soto Embodas I, Rodriguez-Cerezo E. (2019).The Impact Indicator for Priority Pests (I2P2): a tool for ranking pests according to Regulation (EU) No 2016/2031. EUR29793 EN, Publications Office of the European Union, Luxembourg. 2019 Jul.

Sánchez-Bayo F, Wyckhuys KA. (2019). Worldwide decline of the entomofauna: A review of its drivers. Biological conservation. 2019 Apr 1;232:8-27.

Sanders, J et al. (2016) Distribution of the added value in the organic food chain. Study for the European Commission. https://ec.europa.eu/agriculture/external-studies/2016-organic-food-chain_en)

Sarkar, S., Gil, J.D.B., Keeley, J. and Jansen, K., (2021). The use of pesticides in developing countries and their impact on health and the right to food. European Union. Available at: https://www.europarl.europa.eu/thinktank/en/document.html?reference=EXPO_STU(2021)653622

Sawinska, Z. et al. (2020) 'Agricultural practice in Poland before and after mandatory IPM implementation by the European Union', Sustainability (Switzerland), 12(3). doi: 10.3390/su12031107.

Sawinska, Z., Świtek, S., Głowicka-Wołoszyn, R. and Kowalczewski, P.Ł., (2020). Agricultural practice in Poland before and after mandatory IPM implementation by the European Union. Sustainability, 12(3), p.1107.

Scheepmaker, J.W.A., Hogervorst, P.A.M. and Glandorf, D.C.M., (2016). Future introductions of genetically modified microbial biocontrol agents in the EU: Are current EU legislation and risk assessment fit for purpose?. RIVM letter report 2016-0057.

Science for Environment Policy (2020) Pollinators: importance for nature and human well-being, drivers of decline and the need for monitoring. Future Brief 23. Brief produced for the European Commission DG Environment. Bristol: Science Communication Unit, UWE Bristol.

Seufert, V., Ramankutty, N. and Foley, J. A. (2012), 'Comparing the yields of organic and conventional agriculture', Nature, 485: pp. 229–32.

Shanes K., Doberning K., Gözet D. (2018). Food waste matters - A systematic review of household food waste practices and their policy implications. Journal of Cleaner Production, 182: 978-991.

Shirangi, A.; Nieuwenhuijsen, M.; Vienneau, D. (2009). Bystander Agricultural Pesticides Exposure and the Risk of Adverse Reproductive Outcomes: A Review of the Literature, Epidemiology: Volume 20 - Issue 6 - p S184 doi: 10.1097/01.ede.0000362622.69114.30

Simone Hintze, Gaétan Glauser, and Daniel Hunkeler, (2020). "Influence of Surface Water – Groundwater Interactions on the Spatial Distribution of Pesticide Metabolites in Groundwater," Science of The Total Environment 733: 139109, https://doi.org/10.1016/j.scitotenv.2020.139109.

Slow Food Europe (2021), What do the new EU Farm to Fork and Biodiversity Strategies mean for slow food?

SM Say et al., (2018). "Adoption of Precision Agriculture Technologies in Developed and Developing Countries," Online J. Sci. 8, no. 1, http://tojsat.net/journals/tojsat/volumes/tojsat-volume08-i01.pdf#page=16;

Soil Association (2021). Seven ways to save our soils.

SPICE 7 (2018). 7th European Workshop on Standardized Procedure for the Inspection of Sprayers in Europe Athens, Greece September 26-28, 2018

Stas et.al (2017). New approach to fulfil art 8 of Directive 2009/128: a risk assessment procedure for pesticide application equipment, Dimitrovski (2017). Inspection of pesticide application equipment, Cerruto, Manetto, Longo and Papa (2020). Sprayer Inspection in Sicily on the Basis of Workshop Activity

Statistical Annex accompanying the IA of the future CAP proposal, https://ec.europa.eu/agriculture/statistics/facts-and-figures_en

Stroud JL (2019) Soil health pilot study in England: Outcomes from an on-farm earthworm survey. PLoS ONE 14(2): e0203909

Swartjes FA, Van der Aa M. (2020). Measures to reduce pesticides leaching into groundwater-based drinking water resources: An appeal to national and local governments, water boards and farmers. Science of The Total Environment. 2020 Jan 10;699.

T. Anken and T. Waldburger, (2020). "Working Quality, Drift Potential and Homologation of Spraying Drones in Switzerland," in 40. GIL-Jahrestagung, Digitalisierung Für Mensch, Umwelt Und Tier., ed. M. Gandorfer et al. (Bonn: Gesellschaft für Informatik e.V., 2020), 25–30.

Tait, J. and Barker, G., (2011). Global food security and the governance of modern biotechnologies: Science & Society Series on Food and Science. EMBO reports, 12(8), pp.763-768.

Tamirat, T.W., Pedersen, S.M. and Lind, K.M. (2018). Farm and operator characteristics affecting adoption of precision agriculture in Denmark and Germany. Acta Agriculture Scandinavica, Section B. Soil &. Plant Sci., 68(4): 349–357. doi:10.1080/09064710.2017.140 2949.

Theodoros Skevas (2019): Evaluating alternative policies to reduce pesticide groundwater pollution in Dutch arable farming, Journal of Environmental Planning and Management, DOI: 10.1080/09640568.2019.1606618

Thompson B (2009). Impact of the Financial and Economic Crisis on Nutrition – Policy and Programme Responses. Rome: FAO.

Thomsen M, Faber JH, Sorensen PB. (2012). Soil ecosystem health and services–Evaluation of ecological indicators susceptible to chemical stressors. Ecological Indicators. 16:67-75.

Tiilikkala, K., Lindqvist, I., Hagner, M., Setälä, H. and Perdikis, D., (2011). Use of botanical pesticides in modern plant protection. Pesticides in the Modern World—Pesticides Use and Management, pp.259-272.

Tratwal, A. and Bocianowski, J., (2018). Cultivar mixtures as part of integrated protection of spring barley. Journal of Plant Diseases and Protection, 125(1), pp.41-50.

Tresch, P., Chartier, N. and Combourieu, Q., (2018). What polyculture livestock systems tomorrow face the challenges of reducing the use of phytosanitary products?.

Trinomics (2019). Fitness Check Evaluation of the Water Framework Directive and the Floods Directive, Final evaluation report

Udeigwe, T.K., Teboh, J.M., Eze, P.N., Stietiya, M.H., Kumar, V., Hendrix, J., Mascagni Jr, H.J., Ying, T. and Kandakji, T., (2015). Implications of leading crop production practices on environmental quality and human health. Journal of environmental management, 151, pp.267-279.

Underwood, E and Mole, N (2016). Effective policy options for reducing environmental risks from pesticides in the UK. Institute of European Environmental Policy.

United Nations Children's Fund (UNICEF), (2018). Understanding the Impacts of Pesticides on Children: A discussion paper. Available at: https://sites.unicef.org/csr/files/Understanding_the_impact_of_pesticides_on_children-_Jan_2018.pdf

Van Bruggen, A.H., He, M.M., Shin, K., Mai, V., Jeong, K.C., Finckh, M.R. and Morris Jr, J.G., (2018). Environmental and health effects of the herbicide glyphosate. Science of the total environment, 616, pp.255-268.

Van den Brink PJ, Alix A; Thorbek P; Baveco H; Agatz A; Faber JH; Brown AR; Marshall S; Maltby L (2021) The use of ecological models to assess the effects of a plant protection product on ecosystem services provided by an orchard. Science of the Total Environment 798: 149329

van der Ploeg, J.D., Ventura, F. and Milone, P., (2016). Research for Agri Committee-Structural Change in EU Farming: How can the Cap Support a 21st Century European Model of Agriculture?: Research for Agri Commitee-Farm Structural Change in Western Europe and The CAP.

van der Putten WH, Ramirez KS, Poesen J, Winding A, Lemanceau P, Lisa L, Simek M, Moora M, Setala H, Zaitsev A, Economou-Eliopoulos M. Opportunities for soil sustainability in Europe. European Academies Science Advisory Council (EASAC); 2018.

van Eerdt, M.M., Spruijt, J., van der Wal, E., van Zeijts, H. and Tiktak, A., (2014). Costs and effectiveness of on-farm measures to reduce aquatic risks from pesticides in the Netherlands. Pest management science, 70(12), pp.1840-1849.

Van Klink R, Bowler DE, Gongalsky KB, Swengel AB, Gentile A, Chase JM. (2020). Meta-analysis reveals declines in terrestrial but increases in freshwater insect abundances. Science.368(6489):417-20.

Vanham D., Bouraoui F., Leip A., Grizzetti B., Bidoglio G. (2015). Lost water and nitrogen resources due to EU consumer food waste. Environmental Research Letters, 10 (2015) 08408.

Vasconcelos, Y., (2018). Agrotóxicos na berlinda. Pesquisa FAPESP, São Paulo, ano, 19.

Villaverde, J.J., Sandín-España, P., Sevilla-Morán, B., López-Goti, C. and Alonso-Prados, J.L., (2016). Biopesticides from natural products: Current development, legislative framework, and future trends. BioResources, 11(2), pp.5618-5640.

Virto I, Imaz MJ, Fernández-Ugalde O, Gartzia-Bengoetxea N, Enrique A, Bescansa P. (2015). Soil degradation and soil quality in Western Europe: current situation and future perspectives. Sustainability. 2015 Jan;7(1):313-65.

Vurro, M., Miguel-Rojas, C. and Pérez-de-Luque, A., (2019). Safe nanotechnologies for increasing the effectiveness of environmentally friendly natural agrochemicals. Pest management science, 75(9), pp.2403-2412. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ps.5348?saml_referrer

Waichman, A.V., Eve, E. and da Silva Nina, N.C., (2007). Do farmers understand the information displayed on pesticide product labels? A key question to reduce pesticides exposure and risk of poisoning in the Brazilian Amazon. Crop Protection, 26(4), pp.576-583.

Walters, K.F. and Cherrill, A.N.D.R.E.W., (2018). Response to declining availability of plant protection products: a central role for vegetation management. Asp Appl Biol, 139, pp.103-114.

Wang, J., Liu, Q., Hou, Y., Qin, W., Lesschen, J.P., Zhang, F. and Oenema, O., (2018). International trade of animal feed: its relationships with livestock density and N and P balances at country level. Nutrient cycling in agroecosystems, 110(1), pp.197-211.

Ward, M.G., (2016). Conclusions from the workshop on evaluation and regulation of biological control agents. EPPO Bulletin, 46(2), pp.239-242.

Wegener, J.K., Rautmann, D., Herbst, A. and Pelzer, T., (2015). Application of the Zürich-methodology for risk assessment concerning the inspection of pesticide application equipment in use according to article 8 (3) of Directive 2009/128/EC at the example of Germany. Journal für Kulturpflanzen, 67(10), pp.342-346.

Wehmann, H. J. (2018). Status Quo of Inspection in EU: The Results of SPISE Enquiry. In 7th European Workshop on Standardised Procedure for the Inspection of Sprayers–SPISE 7. Athens, Greece. (September 26–28, 9–22)

Wesseler, J.H.H., Bonanno, A., Drabik, D., Materia, V.C., Malaguti, L., Meijer, M. and Venus, T.J., (2015). Overview of the Agricultural Inputs Sector in the EU. European Union.

West, P.C., Gibbs, H.K., Monfreda, C., Wagner, J., Barford, C.C., Carpenter, S.R. and Foley, J.A., (2010). Trading carbon for food: Global comparison of carbon stocks vs. crop yields on agricultural land. Proceedings of the National Academy of Sciences, 107(46), pp.19645-19648.

Wilson, J.B., Peet, R.K., Dengler, J. and Partel, M. (2012). Plant species richness: the world records. Journal of Vegetation Science, 23:796–802

Wolfram J, Stehle S, Bub S, Petschick LL, Schulz R. (2021). Water quality and ecological risks in European surface waters–Monitoring improves while water quality decreases. Environment International. 152:106479.

Woodruff T.J., Kyle A.D., Bois F.Y. (1994). Evaluating health risks from occupational exposure to pesticides and the regulatory response. Environ. Health Perspect. 102:1088–1096. doi: 10.1289/ehp.941021088.

World Health Organization. (1990). Public Health Impact of Pesticides Used in Agriculture. England: World Health Organization

Xu, Z., Li, Y., Chau, S.N., Dietz, T., Li, C., Wan, L., Zhang, J., Zhang, L., Li, Y., Chung, M.G. and Liu, J., (2020). Impacts of international trade on global sustainable development. Nature Sustainability, 3(11), pp.964-971.

Zhang H, Potts SG, Breeze T, Bailey A. (2018). European farmers' incentives to promote natural pest control service in arable fields. Land Use Policy. 78:682-90.

Zhao, Y.Q., Singleton, P., Meredith, S. and Rennick, G.W., (2013). Current status of pesticides application and their residue in the water environment in Ireland. International journal of environmental studies, 70(1), pp.59-72.

Zimny, T., Sowa, S., Tyczewska, A. and Twardowski, T., (2019). Certain new plant breeding techniques and their marketability in the context of EU GMO legislation–recent developments. New biotechnology, 51, pp.49-56. https://www.sciencedirect.com/science/article/pii/S187167841831940X

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