



Report on policies with internalised externalities at the European level

**UCLouvain individual report,
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Task 2.1 Individual report

Evaluating the role of EU food policies in internalising environmental and social externalities: A literature review

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Introduction

The European Union (EU) has been at the forefront of developing and implementing policies aimed at addressing complex challenges in the agri-food sector. An essential aspect of the EU policy cycle is policy evaluation, a phase integral to understanding the effectiveness, efficiency, and impact of implemented measures. This paper critically examines the impact of EU regulations on externalities, drawing insights from a comprehensive review of the scientific literature. This examination is part of a broader evaluation conducted within the scope of the EU FOODCoST project, under the activities of the Work Package 2, led by INRAe. While the whole report aims at systematically evaluating public policies contributing to the internalization of externalities in the food systems at the European Union level and in four specific countries, this paper, authored by the Sytra team¹ of Université catholique de Louvain (UCLouvain), focuses on European policies directly affecting producers. Evaluations of national policies and those affecting other stakeholders along the food chain—processors, retailers, and consumers—have been conducted by other project partners (see FOODCoST deliverable 2.1; to be published).

The analysis encompasses various policy instruments developed in the EU since the year 2000 and their impact on socioeconomic and environmental dimensions. UCLouvain's initial mapping of EU policies influencing producers in the food and agricultural sectors identified 38 policies spanning themes like GMOs, pesticide usage, fertilizer management, fisheries, animal health, animal welfare, and the Common Agricultural Policy (CAP). The evaluation of these policies' impact on the internalization of externalities relies on a comprehensive review of the scientific literature, utilizing SCOPUS as the primary search engine. A detailed methodology description is available in the forthcoming FOODCoST deliverable 2.1.

This paper presents the findings of the literature review, delving into the description of the policy instruments used in the selected policies, their economic mechanism for internalization, and their impact on externalities. The document is structured into three distinct sections, each corresponding to a specific policy domain: environmental policies, encompassing fertilizers, pesticides, GMOs, and fisheries; social policies, focusing on animal health and welfare; and economic policies, particularly centered around the Common Agricultural Policy. This evaluation sets the stage for deeper exploration into the actual outcomes and implications of current policies in tackling both positive and negative externalities in the food and agricultural sectors.

¹ <https://sytra.be/en>

1 THE ENVIRONMENTAL SPHERE

Responsibility for environmental policy making in Europe has extensively shifted to the EU level, with a growing number of measures aimed mostly at levelling the playing field between member states and achieving the harmonization of national policies (Knill and Lenschow 2005). To achieve the objectives set in the European legislation, Member States are expected to implement corresponding adjustments and changes in their national institutional structures. As evidenced by Knill et al. (2005), this process has however not led to the convergence of regulatory arrangements across European countries. The reason would lie within the distinctive pattern of governance across the EU leading to divergent domestic environmental policies. As a result, the national transpositions of EU prescriptions differ greatly across MSs and lead to very different outcomes.

Chemical safety and biosafety

1.1 Fertilizers

1.1.1 Introduction

While the use of fertilizers has led to significant increases in crop yields, it has parallelly resulted in the emergence of severe negative externalities (Hasler et al. 2016; OECD Environment Directorate 2020). The production and use of synthesized nitrogen (N) fertilizers, in particular, are pointed out as major sources of environmental pollution, though other forms of fertilizers, including organic, can also result in negative externalities.

Among the environmental impacts of the use of fertilizers stems the emission of greenhouse gases during the production process, as well as during and after field application. Overall, the nitrogen fertilizer supply chain is responsible for an estimated 10.6% of agricultural emissions and 2.1% of global anthropogenic GHG emissions (Menegat, Ledo, and Tirado 2022). At farm level, nearly half of the N fertilizer supplied is not used by crops and is lost to the ecosystem through volatilization, run-off, or leaching (Martínez-Dalmau, Berbel, and Ordóñez-Fernández 2021). In addition to their contribution to the release of greenhouse gases, these losses lead to additional environmental degradations. These include direct toxicity to organisms and indirect impacts through factors such as nutrient enrichment, oxygen depletion in aquatic ecosystems, soil or water acidification or intensifying the impact of other stressors such as pathogens, invasive species and climate change (OECD Environment Directorate 2020; Martínez-Dalmau, Berbel, and Ordóñez-Fernández 2021). Negative environmental externalities linked the use and production of fertilizers further include

the depletion of non-renewable resources, such as phosphorus and potassium (Hasler et al. 2016).

Fertilizers can contain substances that may potentially pose a risk for human and animal health. Long-term use of chemical fertilizers and organic manures has been showed to contribute to the accumulation of heavy metals in agricultural soils (Atafar et al. 2010; Focker et al. 2022). Among these, Cadmium (Cd), a highly toxic contaminant, is of most concern. Other heavy metal associated with the use of fertilizers include chromium (Cr), copper (Cu), and zinc (Zn). By increasing the concentrations of these heavy metal in agricultural soils and derived crops and products, fertilizers pose a risk of food contamination (EFSA 2009). In addition to the potential presence of chemical hazards, microbiological hazards may also be present in the form of pathogenic bacteria present in animal manure (Focker et al. 2022). Finally, pharmaceuticals, among which antimicrobials, are another major concern in animal manure, leading to resistance issues (Focker et al. 2022).

1.1.2 Description of fertilizer-related policies at EU-level

In order to manage the risks posed by the production and use of fertilizers to the environment and the health of humans and animals, the EU has developed a number of policies aimed at regulating practices and harmonizing standards across countries. Table 1 highlights the most prominent EU policies for fertilizers management in food systems, by chronological order.

Table 1. List of main EU policies enabling the internalization of externalities linked to fertilizers in food systems

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Council Directive 91/676/EEC	Concerning the protection of waters against pollution caused by nitrates from agricultural sources	Nitrate Directive	Dec 1991	Dec 1993	
Directive 2000/60/EC	Establishing a framework for Community action in the field of water policy	Water Framework Directive	Dec 2000	Dec 2003	
Directive 2006/118/EC	On the protection of groundwater against pollution and deterioration	Groundwater Directive	Jan 2007	Jan 2009	
Regulation (EU) 2019/1009	Laying down rules on the making available on the market of EU fertilizing products	Fertilizers marketing	July 2019	July 2022	Repealing Regulation (EC) 2003/2003; Amending Regulations (EC) 1069/2009 and (EC) 1107/2009

1.1.2.1 Council Directive 91/676/EEC – Nitrate Directive

Council Directive 91/676/EEC, known as the Nitrates Directive, was adopted by the EU in 1991 with the objective of reducing water pollution caused or induced by nitrates from agricultural sources. It includes measures aimed to prevent or reduce nitrate pollution from livestock manures and other fertilizers through the establishment of national Action Programmes, which include mandatory measures for vulnerable zones, and codes of Good Agricultural Practices, which consist mostly of voluntary-based measures to be implemented by farmers.

The implementation of the Nitrate Directive is one of the Statutory Management Requirements that farmers must comply with in order to receive direct payments under the CAP. In addition, the directive's requirements are also included as part of the cross-

compliance measures that farmers must comply with in order to receive certain direct payments under the CAP. For an overview of the role and impact of the CAP on the internalization of food systems' externalities, see Section 3 THE ECONOMIC SPHERESupport to the agricultural sector.

1.1.2.2 Directive 2000/60/EC – Water Framework Directive

Directive 2000/60/EC establishes a framework for Community action in the field of water policy. It includes measures to prevent or reduce pollution from agriculture, including environmental quality standards for pesticides in surface water.

Related policies:

- Directive 2008/105/EC 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
- Directive 2013/39/EU amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy

1.1.2.3 Directive 2006/118/EC – Groundwater Directive

Directive 2006/118/EC aims to protect groundwater against pollution and deterioration, including through measures to prevent or reduce contamination from fertilizers.

1.1.2.4 Regulation (EU) 2019/1009 – Fertilizers marketing

On July 2022, Regulation (EU) 2019/1009 entered into force with the main objectives of harmonizing the regulation of fertilizers among EU Member States and minimizing any present and future adverse health and environmental effects due to the use of fertilizers (Regulation (EU) 2019/1009 2019). This is the main piece of legislation directly targeting externalities associated with fertilizers.

This new fertilizer Regulation has extended the categories of fertilizers covered by EU regulations, from a focus on mineral fertilizers in the repealed Regulation (EC) 2003/2003 to the inclusion of recycled and organic materials. It also provides for a number of obligations for manufacturers, importers and distributors of fertilizers, mainly to limit the content of contaminants in products (in particular for Cadmium) and to introduce more extensive labelling requirements. The harmonization standards introduced by Regulation (EU) 2019/1009 are however optional, meaning that manufacturers and distributors of fertilizer products can choose whether to comply with the EU procedure or follow national regulations for placing their products on the market.

By encouraging the supply of safe and high-quality fertilizer products coming from recycled domestic organic sources, this regulation is considered an important step towards Circular Economy (Marini, Caro, and Thomsen 2020).

1.1.3 Main policy instruments and mechanisms for the internalization of externalities

According to the literature review by Marini, Caro, et Thomsen (2020), besides the Common Agricultural Policy (CAP), the relevant legislations covering the impact of fertilizer consist essentially of command-and-control (C&C) instruments. This is in line with the view of Lally et van Rensburg (2007) stating that, while both economic (input taxes) and regulatory (input regulations and management practices) policy instruments can be used to deal with nitrate pollution, in practice command-and-control (regulatory) measures are mostly implemented. Four reasons are given by Lally et van Rensburg (2007) to explain that situation, with the example of nitrogen fertilization:

1. Imposing an input tax – on for instance nitrogen – would prove very difficult for the EU as the level of taxes required to achieve the objective in terms of organic and inorganic application rates would vary significantly across countries and even between producers within each country.
2. There is no direct link between an input tax and the level of nitrate emissions, which means that there is a high level of uncertainty regarding policy outcome.
3. The tax only targets the quantity of fertilizer purchased, not the field application.
4. A tax on nitrogen inputs would have little or no impact on other risk factors that may cause pollution of waters by nitrates, particularly the timing of application.

The following evaluation section mostly concentrates on regulatory instruments. A distinction is made between ex-ante risk assessment (conformity checks), market & post-market risk management (labels) and implementing tools, including the Good Agricultural Practices and Action Programmes established through the EU Nitrate Directive.

Table 2 lists these main instruments used in fertilizer regulations, with references to the group of actors primarily targeted by the instrument, its ultimate beneficiaries, and the type of externalities addressed. Since economic tax-based policy instruments are not currently mandated at EU-level, such instruments are not reviewed in the present paper. The evaluation section will nonetheless present a brief overview of academic position on this topic.

Table 2. List of policy instruments used in the main EU policies regulating fertilizers in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
C&C Ex-ante risk assessment	Fertilizers' conformity	Regulation (EU)2019/1009	Agro-industry	Society at large	Food safety; Animal Welfare	Climate change; Acidification & eutrophication; Direct effects on biodiversity & ecosystems; Toxicity
C&C Market & post-market risk management	Labelling	Regulation (EU)2019/1009	Agro-industry	Farmers	Consumers' rights	
C&C Implementing tools	Agricultural Practices & Action Programmes	Directive 91/676/EEC	Farmers	Society at large	Food safety; Animal Welfare	Climate change; Acidification & eutrophication; Direct effects on biodiversity & ecosystems; Toxicity

1.1.3.1 Ex-ante risk assessment (Fertilizers' conformity) – IOE mechanism

By requiring an ex-ante assessment of fertilizing products before their marketing, Regulation (EU) 2019/1009 aims at harmonizing the EU fertilizer market and minimizing adverse health and environmental effects due to their use. This instrument is designed to reduce both social and environmental externalities by addressing various impacts caused by fertilizers, including food safety, animal health, climate change, acidification, eutrophication, direct effects on biodiversity and ecosystems, and toxicity. This instrument therefore aims to reduce the social and environmental externalities caused by the use of fertilizers by requiring industries (fertilizers' manufactures and retail) to release products that comply with strict standards, thus minimizing the subsequent impacts of fertilizers at farm-level.

1.1.3.2 Market & post-market risk management (Labelling) – IOE mechanism

Labelling is an instrument used in agri-food systems to provide accurate information to producers and consumers. By ensuring the availability and transparency of information, labelling allows for freedom of choice, as users can make informed decisions about the products they purchase based on their values and preferences.

1.1.3.3 *Implementing tool (Good Agricultural Practices and Action Programmes) – IOE mechanism*

Good Agricultural Practices and Action Programmes are established in order to stimulate a change in the behavior of agricultural producers, encouraging practices that align with the objectives of the regulation, i.e. reducing water pollution caused or induced by nitrates from agricultural sources.

On the social side, GAPs and Action Programmes help to improve food safety and animal health by reducing the levels of contaminants from fertilizers in the food and feed chain.

On the environmental side, this instrument contributes to the reduction of multiple externalities, including climate change, acidification and eutrophication, direct effects on biodiversity and ecosystems, and toxicity. By reducing the amount of contaminants from fertilizers that enter water bodies, GAPs and Action Programmes help to prevent or mitigate the negative impacts of these externalities. Moreover, GAPs and Action Programmes can contribute to the improvement of farming practices and the adoption of more sustainable approaches in agriculture. This can lead to better use of resources, reduced environmental impacts, and increased resilience to environmental changes.

1.1.4 *Evaluation of the impact of policy instruments on the internalization of externalities associated with fertilizers*

Overall, the EU is recognized as one of the most active region in the area of soil protection, despite a yet lacking comprehensive and legally binding legislation scheme (Marini, Caro, and Thomsen 2020).

In their 2020 paper, Marini, Caro, et Thomsen present an overview of the limits pertaining to current legislations aimed at addressing the impact of fertilizers, in particular Regulation (EU) 2019/1009. Although command-and-control law is reported as a necessary instrument for the protection of agricultural soils, it is seen by the authors as inadequate to guarantee full soil protection in the EU. Given the limitations of current legislation, the authors stress the need for complementary policy instruments aimed at protecting and conserving agricultural soil health. In that sense, the recently proposed, and subsequently withdrawn, EU Soil Framework Directive (SFD) was considered a meaningful complementary policy tool. Member States rejected the SFD on the ground of subsidiarity principle, claiming that it would have interfered with the national soil policy and, since soil would not constitute a cross-border issue – unlike air and water – the EU would have no right to regulate it. The authors nonetheless question that reasoning, given the fact that externalities from soil health are embedded in the global food trade.

1.1.4.1 *Ex-ante risk assessment – Fertilizers’ conformity*

1.1.4.1.1 Environmental impacts

By assessing compliance with established limits for contaminants presence in fertilizers, the ex-ante procedure should allow for a reduction in **environmental pollution**. However, the instrument is judged ineffective in that sense.

Similarly to other soil protection legislations, the instruments used in Regulation (EU) 2019/1009 are accused of considering soil protection as a beneficial side effect, rather than a primary objective (Marini, Caro, and Thomsen 2020). These policies are considered to have a single objective: guaranteeing the highest agricultural land productivity while safeguarding human beings from contaminants. Therefore, by simply limiting the chemical threats for humans, the assessment of fertilizers fails to consider sustainability as a whole, including the restoration, support, and conservation of natural resources and ecosystem services (Marini, Caro, and Thomsen 2020). In doing so, the assessment of fertilizers, particularly manure-based, fails to appropriately consider soil **biodiversity** issues (Köninger et al. 2021).

To effectively integrate the reduction of negative externalities associated with the use of fertilizers, EU policies and conformity assessment would need to recenter their goals on the overall protection of the environment.

1.1.4.1.2 Economic impacts

Market-wise, since Regulation (EU) 2019/1009 has opened from 2022 onwards a market for manure and biostimulant products, while regulating more strictly mineral fertilizers, the access and value of organic fertilizers are likely to increase (Köninger et al. 2021). The established level-playing field should further ensure better access to the internal market to innovative companies. In this respect, the regulation is expected to impact the overall **structure of the EU market**. However, it should be noted that Regulation (EU) 2019/1009 is based on the principle of optional harmonization and will thus not overrule national legislations.

1.1.4.2 *Market & post-market risk management – Labelling*

1.1.4.2.1 Social impacts

Regulation (EU) 2019/1009 introduces labelling requirements that are much more extensive than the previous Regulation (EC) 2003/2003. This reflected new social demands and concerns, as well as the fact that the new rules drastically opened the EU market for products that are innovative and unknown, and therefore require better user information (European Commission 2023b). However, overloaded labels were reported to cause legibility problems for interested parties, as the provision of numerous details on a label makes it difficult to identify the essential information (European Commission 2023b). While labelling is essential to ensure the **availability of accurate and**

transparent information to producers and consumers, the overloading of information might actually **hinder transparency** efforts.

1.1.4.2.2 Economic impacts

On an economic aspect, labels were reported to cause management difficulties for economic operators who need to cover the increasing **transaction costs** of adequate labelling (European Commission 2023b).

1.1.4.3 Implementing tool – Good Agricultural Practices & Action Programmes

As a foreword, Kanter et al. (2020) note that most policies dedicated to reducing agricultural pollution, particularly nitrogen, focus on changing farmer behavior. However, they stress that farm-level policies are challenging to implement, and that farmers are just one of several actors in the agri-food chain. The activities of other actors — from fertilizer manufacturers to wastewater treatment companies — are seen as equally important in reducing nitrogen losses at the farm level and beyond and thus need to be equally targeted (Kanter et al. 2020).

1.1.4.3.1 Environmental impacts

According to the Nitrate Directive, Member States are required to establish codes of Good Agricultural Practices (GAP) that should be implemented by farmers and specific Action Programs including mandatory measures for vulnerable zones.

Although GAP set by MSs are generally reported to have improved the use efficiency of fertilizers (Monteny 2001; Deneufbourg et al. 2013; De Vries et al. 2015; Buckley et al. 2016; Gomes, Antunes, and Leitão 2023; López-Ballesteros et al. 2023), the nitrogen surpluses did not necessarily decrease accordingly (Köninger et al. 2021; Ricci et al. 2022). Indeed, EU Member States reports concerning their national water bodies status reveal that the applied measures remain globally insufficient to reduce **groundwater contamination** (Gomes, Antunes, and Leitão 2023). In 2020, the European Commission had to urged France, Italy, Belgium and Spain to comply with nitrate thresholds for losses to water tables set in the Nitrates Directive (Köninger et al. 2021).

In Ireland, results from Buckley et al. (2016) suggest some positive impact of the GAP regulations on N management in dairy farms, with a potential double dividend effect of increased returns to agricultural production while reducing the risk of N transfer to the aquatic **environment** (undissociated impacts). However, while this improvement in nutrient management efficiency is in part likely due to application limits and other measures imposed under the GAP regulations, the authors recognize the influence of other factors, including fertilizer prices, stocking rates, contact with agricultural advisors, and climatic variables. It is therefore very difficult to directly attribute to the Good Agricultural Practices any impact observed at farm-level.

Furthermore, impacts of agri-environmental practices such as those included in the Good Agricultural Practices & Action Programmes are likely to be highly context-dependent, with very different outcomes in the different European countries and regions (Baaken 2022; Ricci et al. 2022).

1.1.4.3.2 Economic impacts

By enhancing efficiency in fertilizers' use and best management practices, the Good Agricultural Practices & Action Programmes may generate savings for farmers in the form of reduced fertilizer expenditures and increased yields (Kanter et al. 2020). Furthermore, Kanter et al. (2020) suggest that such an instrument may also increase revenue for the fertilizer companies that produce and provide fertilizers, given that many enhanced efficiency fertilizer and best management practices services are patent-protected and thus have a higher profit margin for those companies.

Besides these direct economic impacts, the implementation of Good Agricultural Practices and Action Programmes might induced positive **knowledge capital spillovers**. Indeed, through its call for a 50% reduction of nutrient loss in the Green Deal and its mandate to introduce Good Agricultural Practices & specific Action Programmes, the European Commission is stimulating new studies to investigate the recycling and nutrient recovery potentials of various fertilizers options, as well as additional measures and new technologies that can minimize the pressures on waters and soil (Köninger et al. 2021; Ricci et al. 2022). Furthermore, knowledge of on-farm fertilizing and manure treatment methods needs to be spread, e.g., through training and agricultural extension work.

1.1.4.4 *Synthesis of EU fertilizer policies' impacts on social, environmental and economic factors*

Table 3 provides a synthesis of the impacts of EU fertilizer policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 3. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU fertilizers policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Ex-ante risk assessment	(+) (-) (/)	(+) (-) Biodiversity (/) Environmental pollution	(+) (-) (/) Market structure
Market & post-market risk management	(+) Transparency (-) Transparency (/)	(+) (-) (/)	(+) (-) Transaction costs (/)
Implementing tools	(+) (-) (/)	(+) Undissociated (-) (/) Water contamination	(+) Knowledge capital (-) (/)

1.1.4.5 Brief overview of tax-based instrument

Taxes can be used to internalize the external environmental (and health) costs of pesticides and fertilizers and have been adopted in a few countries (OECD Environment Directorate 2020).

In the EU, some European countries including Sweden, Norway, Finland and Austria, implemented the 1970s and 1980s taxes on mineral N fertilizer to address the pollution of water bodies (Meyer-Aurich et al. 2020). These tax policies were substituted by direct regulation of fertilizer use in the course of the EU harmonization process in the last decades. Meyer-Aurich et al. (2020) pointed to the current re-emergence of the debate on N taxation, which is fueled by the perceived lack of implementation of effective measures to reduce N use and its environmental damage. However, such taxing system is not unanimously accepted as best practice. Previous researches suggest that regulatory limits on N fertilizers compared to a tax-based economic instrument could actually achieve compliance more effectively and equitably (Lally and van Rensburg 2007; Buckley et al. 2016; Adenuga et al. 2020). This would be especially true for farms that are already operating at optimal fertilizing rates and in compliance with EU Nitrates based regulations (Lally and van Rensburg 2007; Buckley et al. 2016).

Demand elasticity for fertilizers (and pesticides) being fairly low, a very substantial tax would be required in order to achieve compliance with the stipulated application rates (Lally and van Rensburg 2007; OECD Environment Directorate 2020). Taxing the sales of inorganic nitrogen is thus considered to result in a larger compliance cost on farmers and on public authorities than would a regulatory measure. Furthermore, the tax is considered to result in inequities, as farms already in compliance with the Action Programme would incur substantial losses in farm income (Lally and van Rensburg 2007). Given the higher compliance cost and inequities generated by a tax-instrument compared to regulatory measures, it is considered unlikely that such a measure would be politically acceptable.



1.2 Pesticides

1.2.1 Introduction

During the period of agricultural intensification, modern agriculture has progressively favored a dominant model that prioritizes productivity as the main objective. To maintain high level of production, agricultural production systems now rely heavily on the use of synthetic pesticides that protect the crops by controlling weeds, pathogens and animal pests (Bourguet and Guillemaud 2016; Carvalho 2017). These plant protection products (PPP) have been very successful in increasing agricultural yields. Their use has grown considerably since the middle of the twentieth century, becoming one of the most widely used and effective tools in agriculture (Bourguet and Guillemaud 2016).

Beside the benefits of pesticides in terms of agricultural production gains, concerns have been raised on the associated negative externalities touching a variety of dimensions, such as human health and the environment (Bourguet and Guillemaud 2016; OECD Environment Directorate 2020; Alliot et al. 2022).

By spreading in the environment, agrochemical residues from pesticides cause significant contamination of terrestrial and aquatic ecosystems (Carvalho 2017; OECD Environment Directorate 2020; Mamy et al. 2022). Large losses of biodiversity, such as insects, birds, amphibians, aquatic plants, fish, and small mammals, are associated with the presence of pesticide in the environment (Carvalho 2017; Mamy et al. 2022). Their translocation across all environmental compartments, as well as their persistent and bio-accumulative character, have made pesticides the cause of global and lasting environmental pollution.

The production of synthetic pesticides is energy intensive and can emit large amounts of greenhouse gases (GHG), thereby contributing to human-induced climate change (Cech, Leisch, and Zaller 2022). In turn, climate change is expected to increase the intensity of pesticide use due to, among others, an alteration of plants health and resistance (Delcour, Spanoghe, and Uyttendaele 2015).

Some studies tend to demonstrate, on the other hand, the positive impact of pesticide on GHG emissions, through the avoidance of land conversion (more pesticides used leads to less land needed to produce the same amount of agricultural goods) (Hughes et al. 2011).

The use of pesticides has a significant impact on human health as well. Human exposure to pesticides, through ingestion of contaminated food and water or direct contact, is linked to chronic illnesses such as cancer, and heart, respiratory and neurological diseases (OECD Environment Directorate 2020; EEA 2023). Farmers, rural workers, and

rural families are more strongly affected by that risk, with many cases of intoxication being reported (Carvalho 2017). However, the full extent of health impacts related to pesticide exposure remains largely unknown, given the wide variety of chemicals applied (with their inherently different properties) and the different human exposure pathways (Fantke, Friedrich, and Jolliet 2012; Alliot et al. 2022).

Few of these consequences of pesticide use are confined to the farm on which they arise, the majority being ‘externalized’ to become a cost to society as a whole (Stoate et al. 2001).

1.2.2 Description of pesticide-related policies at EU-level

Over the decades, concerns about the impact of pesticides have emerged and grown as knowledge and evidence has been gathered by academic and other research institutions (Alliot et al. 2022). Recognizing these concerns, the EU has gradually built up a framework of legislation to authorize pesticides, promote their sustainable use and reduce the risk that they pose for human health and the environment (European Court of Auditors 2020). Table 4 highlights the most prominent EU policies for pesticides management in food systems, by chronological order.

The urgency of reducing dependency on pesticide is further stressed within the context of the European Green Deal, under the farm to fork strategy, zero pollution action plan and biodiversity strategy for 2030. These strategies set key targets, including a 50% reduction in the use and risk of chemical pesticides; a 50% reduction in the use of the more hazardous ones; at least 25% of the EU’s agricultural land to be under organic farming.

Table 4. List of main EU policies enabling the internalization of externalities linked to pesticide in food systems.

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Directive 2000/60/EC	Establishing a framework for Community action in the field of water policy	Water Framework Directive	Dec 2000	Dec 2003	
Regulation (EC) 396/2005	On maximum residue levels of pesticides in or on food and feed of plant and animal origin	Maximum Residue Levels	April 2005	Jul 2008	
Directive 2009/128/EC	Establishing a framework for Community action to achieve the sustainable use of pesticides	Sustainable Use Directive	Nov 2009	Dec 2011	
Regulation (EC) 1107/2009	Concerning the placing of plant protection products on the market	Market placing	Dec 2009	June 2011	Repealing Council Directives 79/117/EEC and 91/414/EEC
Directive 2009/127/EC	With regard to machinery for pesticide application	Machinery	Dec 2009	June 2011	Amending Directive 2006/42/EC
Regulation (EU) 2022/2379	On statistics on agricultural input and output	Statistics	Dec 2022	Jan 2023	Amending Regulation (EC) 617/2008 and repealing Regulations (EC) 1165/2008, (EC) 543/2009 and (EC) 1185/2009

The overarching goal of this pesticide framework is to ensure a high level of protection of both human and animal health and the environment, and at the same time to safeguard the competitiveness of the EU's agriculture. With these regulatory

instruments, European authorities intend to mandate and control the environmental performance to be achieved by the Community's agriculture (Lefebvre, Langrell, and Gomez-y-Paloma 2015).

1.2.2.1 Directive 2000/60/EC – Water Framework Directive

Directive 2000/60/EC establishes a framework for Community action in the field of water policy. It includes measures to prevent or reduce pollution from agriculture, including environmental quality standards for pesticides in surface water.

Related policies:

- Directive 2008/105/EC 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
- Directive 2013/39/EU amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy

1.2.2.2 Regulation (EC) 396/2005 – MRL

Regulation (EC) 396/2005 came into force in April 2005, setting pan-EU harmonized maximum pesticide residue levels² in or on plant- and animal-based food and feed, thereby regulating dietary exposure of consumers. It superseded the previous Council Directive 76/895/EEC relating to the fixing of maximum levels for pesticide residues in and on fruit and vegetables. As a result, since September 2008 national MRLs are no longer in force and only harmonized European legal limits apply (Karabelas et al. 2009).

1.2.2.3 Directive 2009/128/EC – SUD

The EU's regulatory framework for pesticides is grounded in Directive 2009/128 (known as the Sustainable Use Directive or SUD), which came into force in November 2009 to 1) establish a framework for the sustainable use of pesticide by reducing their risks to human health and the environment and 2) promote the use of integrated pest management and different techniques, such as non-chemical alternatives.

Regarding the first objective, the SUD introduced various requirements that needed to be transposed into the Member States' national legislation and subsequently implemented by their national authorities. These requirements included, for instance, banning aerial spraying but also reducing or banning the use of pesticides in various specific areas (Karabelas et al. 2009). Furthermore, the SUD required Member States to introduce "National Action Plans (NAP) aimed at setting quantitative objectives, targets,

² Maximum Residue Levels are the upper legal levels of a concentration for pesticide residues in or on food, or feed.

measures, timetables and indicators to reduce risks and impacts of pesticide use on human health and the environment and at encouraging the development and introduction of Integrated Pest Management (IPM) and of alternative approaches or techniques to reduce dependency on the use of pesticides” (Directive 2009/128/EC 2009a, introduction point 5). To support MSs in preparing their NAP, Regulation (EC) 1185/2009 adopted rules on the collection and dissemination of statistics on the sales and use of pesticides.

Regarding the second objective, the SUD was the first piece of EU legislation to introduce a set of principles for integrated pest management that should lead to a change in the use of pesticides by their users, mostly farmers (Directive 2009/128/EC 2018). It introduces two types of provisions (Lefebvre, Langrell, and Gomez-y-Paloma 2015):

- Obligations imposed to all the professional users of pesticides in the European Union to use pesticide properly (i.e. in compliance with the general principles of integrated pest management defined in annex III of the directive).
- Obligations imposed at Member State level (ensure that the general principles of IPM are implemented by all professional users and provide incentives to encourage professional users to implement crop or sector-specific guidelines for integrated pest management on a voluntary basis).

To address the increasing urgency of tackling pesticide use and dependency, the European Commission has committed to revising the directive on the sustainable use of pesticides, with a proposed regulation on the sustainable use of plant protection products currently under discussion (EEA 2023).

1.2.2.4 Regulation (EC) 1107/2009 – Market placing

Regulation (EC) 1107/2009 came into force in June 2011, with a view to structure the production and placement of PPPs on the market; it repealed Council Directive 91/414/EEC. While maintaining the basic principle based on protection of health (human and animal) and of the environment, the main objectives of the new regulation were oriented toward a better harmonization and simplification of the procedures concerning the regulation of pesticides, thereby reducing the costs for the private and public sector and strengthening the internal market (Pelaez, Silva, and Araújo 2013).

To do so, the Regulation sets out criteria to be met by pesticides manufacturers for the approval of active substances, safeners, synergists, co-formulants and adjuvants, which plant protection products contain or consist of, and rules to be followed for the authorization of PPP in Member States.

The placing of PPP on the market indeed relies on two main steps (Larras et al. 2022). First, all of the components of the PPP (active substances, synergists, safeners) have to

be approved at the EU level and the co-formulants must not be on the list of unauthorized ones. Second, the commercial form of the PPP is assessed at a zonal level (within a group of Member States, namely North, Central, and South zones) prior to its authorization in one or several Member States of the targeted zone. To be approved, an active substance must show its efficacy towards the target species as well as its safety towards human and animal health, and environment. Also, it shall have no “armful effect on human health [...], shall not have any unacceptable effects on plants or plant products [...], shall not cause unnecessary suffering and pain to vertebrate [...], and shall have no unacceptable effects on the environment” (European Commission 2009, Article 4). Therefore, the environmental risk assessment (ERA) of an active substance is a mandatory step, among others such as risk assessment for human health (Larras et al. 2022). The list of approved active substances is established in Commission implementing Regulation 540/2011.

Related policies:

- Regulation (EU) 2019/1381 on the transparency and sustainability of the EU risk assessment in the food chain.
- Commission Implementing Regulation (EU) No 540/2011 of 25 May 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the list of approved active substances.

1.2.2.5 Directive 2009/127/EC – Machinery

Directive 2009/127/EC, known as the Machinery Directive, sets rules for the use of machinery for pesticide application. Under the Machinery Directive, manufacturers of machinery must fulfill certain essential requirements for the protection of the health and safety of persons and, where appropriate, domestic animals and property.

1.2.2.6 Regulation (EU) 2022/2379 – Statistics

Regulation (EU) 2022/2379 establishes an integrated framework for aggregated European statistics relating to the input and output of agricultural activities. It is part of a major programme aimed at modernizing EU agricultural statistics – the *Strategy for Agricultural Statistics for 2020 and beyond*.

1.2.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

The relevant legislation covering the impact of pesticides in food systems consists essentially of regulatory – command-and control (C&C) – instruments. The following evaluation section concentrates on these instruments, with a distinction between ex-ante risk assessment, market & post-market risk management – in the form of controls and labels –, as well as implementing instruments consisting of the implementation of

National Action Plans (NAP). Table 5 lists the main instruments used in pesticide regulations, with references to the group of actors primarily targeted by the instrument, its ultimate beneficiaries, and the type of externalities addressed. When a type of externality is not fully detailed in the literature, the mention “undissociated” is used (for instance, pesticide legislations that broadly mention environmental impact without discerning sub-types such as climate change, toxicity, effects on biodiversity and ecosystems, etc.).

Since economic tax-based policy instruments are currently not mandate at EU-level, such instruments are not reviewed in the present paper.

Table 5. List of policy instruments used in the main EU policies regulating pesticide in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
C&C Ex-ante risk assessment	Approval of active substance	Regulation (EC)1107/2009	Agro-industry	Society at large	Food safety	Undissociated
	Approval of PPP	Regulation (EC)1107/2009	Public authorities	Society at large	Food safety	Undissociated
	MRL establishment	Regulation (EC)396/2005	Agro-industry	Consumers	Food safety	
C&C Market & post-market risk management	MRL controls	Regulation (EC)396/2005	Public authorities	Consumers	Food safety	
	Labelling	Regulation (EC)1107/2009	Agro-industry	Farmers	User's right	
C&C Implementing tools	National Action Plan	Directive 2009/128/EC	Public authorities & Farmers	Society at large	Food safety	Undissociated

The mention “undissociated” is used to report an impact that is not fully detailed in the literature.

1.2.3.1 Ex-ante risk assessment (active substances, PPP, MRLs) – IOE mechanism

The EU's requirement for an ex-ante assessment of the risks associated with the release of active substances and PPP, as well as the maximum pesticide residue levels allowed on food and feed, serves the purpose of minimizing adverse health and environmental effects due to pesticide use in agriculture. This instrument aims to reduce the social and

environmental externalities caused by the use of pesticide by requiring industries (pesticides' manufactures and retail) to release products that comply with strict standards, thus minimizing the subsequent impacts of pesticides at farm-level.

1.2.3.2 Market & post-market risk management – IOE mechanism

1.2.3.2.1 MRL controls

Controlling compliance with MRL standards is an ex-post measure that allows for the management of food safety risks after the use of pesticides in agriculture. As such, this instrument supports the minimization of food safety issues associated with the use of pesticides by (1) encouraging an effective enforcement of EU standards and (2) identifying any non-compliance or infringements and taking action to limit their consequences on public health.

In addition, the ex-post management of food safety risks through the control of compliance with MRL standards provides a feedback mechanism for the ex-ante assessment of pesticide risks, allowing for improvements to be made to the assessment process based on the results of monitoring and evaluation. This instrument also contributes to enhancing consumer confidence in the safety of food and feed products by ensuring that they meet established standards.

1.2.3.2.2 Labelling

Labelling is an instrument used in agri-food systems to provide accurate information to producers and consumers. By ensuring the availability and transparency of information, labelling allows for freedom of choice, as users can make informed decisions about the products they purchase based on their values and preferences.

1.2.3.3 Implementing tool (National Action Plans) – IOE mechanism

National Action Plans aim to reduce the risks and impacts of pesticide use on human health, animals and the environment by encouraging the development and introduction of Integrated Pest Management and alternative approaches to reduce the dependency on pesticides. This instrument stimulates a change in the behavior of producers and fosters practices aligned with the objectives of the regulation.

National Action Plans act on both social and environmental externalities. On the social side, they can help improve health and food safety by improving the use of pesticides in agriculture. A better management of pesticides can lead to a reduction in health risks associated with the presence of pesticide residues in food, water and the environment (Alliot et al. 2022).

On the environmental side, National Action Plans can contribute to the reduction of various environmental externalities, including climate change, effects on biodiversity

and ecosystems and toxicity, by improving the way pesticides are used and by reducing the dispersal of residues in the environment. Overall, they can contribute to the improvement of farming practices and the adoption of more sustainable approaches in agriculture, thereby increasing the resilience to environmental changes.

1.2.4 Evaluation of the impact of the policies instruments on the internalization of externalities

1.2.4.1 *Ex-ante risk assessment – Active substances, PPP, MRLs*

Before placing agrichemicals on the market, the EU requires a major consideration of their risks through a strict approval process for active substances and PPP (through Regulation (EC) 1107/2009), and the establishment of Maximum Residue Levels (Regulation (EC) 396/2005).

Overall, the REFIT³ Evaluation of the EU legislation on plant protection products and pesticides residues (European Commission and ECORYS 2018) concluded that these instruments are effective and relevant, as they allow a higher level of harmonization across MSs, which enhances the functioning of the internal market and the protection of the health of consumers. This study demonstrates the positive impact of PPP and pesticides residues regulations on social, environmental and economic factors, mostly due to stringent criteria addressed at pesticide manufacturers for the approval of active substances. A number of studies however criticize the pesticide authorization process itself, arguing that, in practice, it has not achieved its objective of reducing the risk associated with pesticide use since unsafe pesticides are still allowed onto the EU market (Storck, Karpouzas, and Martin-Laurent 2017; Robinson et al. 2020). These studies claim that, while failing to directly target the negative environmental externalities linked to the use of pesticide in agricultural production systems, the regulation of PPP approval at EU level might have indirectly exacerbated negative **social, environmental, and economic** externalities.

1.2.4.1.1 Social impact

At social level, the application of the approval criteria for active substances has produced positive effects on **food safety**, with a reduction in public health costs (European Commission and ECORYS 2018). While this impact cannot be quantified, it is assumed that the non-approval, non-renewal, or withdrawal of substances based on health-based criteria since the introduction of the regulation has contributed to the avoidance of risks stemming from substances that are considered genotoxic, toxic to reproduction, or carcinogenic.

³ The European Commission's regulatory fitness and performance programme (REFIT) aims to ensure that EU laws deliver on their objectives at a minimum cost for the benefit of citizens and businesses.

While the application of approval criteria for active substances may have led to a reduction in negative health externalities, the setting of these criteria has been subject to much debate. In particular, the lack of **transparency** created by the limited requirements to publish data and information, the high level of expertise needed to understand the PPP authorization procedure and the lack of provision for public or stakeholder engagement during the different evaluation phases has hampered the acceptability of the process by society (Storck, Karpouzas, and Martin-Laurent 2017; Hamlyn 2019). Besides, the multi-actor decision chain of pesticide authorization, although originally designed to guarantee consensus about pesticide authorizations or bans, has resulted in growing suspicion because it is perceived as a potential source of conflict of interest (Storck, Karpouzas, and Martin-Laurent 2017).

Another aspect criticized in pesticide regulations for lack of transparency is the zonal system that was developed for pesticide authorization in Regulation (EC) 1107/2009, as it sheds little light on how the system was conceived (Hamlyn 2019).

Overall, these results suggest that EU pesticide regulations failed to deliver adequate public reporting, and therefore the possibility of public scrutiny. Improving public access and understanding of data and facilitating public participation in decision-making is necessary to enhance **trust** in pesticide authorization process. De Boer, Morvillo, et Röttger-Wirtz (2023) argue that as a result of legislative reform, the **transparency** of EU agency science is now approached more proactively, thereby strengthening the overall legitimacy of expert-based measures in EU risk regulation.

1.2.4.1.2 Environmental impact

At environmental level, the regulation of PPP approval seems to have similarly conducted to both positive impact due to stringent rules for the application of active substance, and negative impact due to related procedures. The non-approval or non-renewal of substances due to environmental concerns has helped to avoid risks to groundwater, soil and wildlife, thereby reducing negative externalities linked to **toxicity** and direct effects on **biodiversity** and ecosystems (European Commission and ECORYS 2018).

Nonetheless, two mechanisms linked to the authorization procedure might alternatively induce **toxicity** for biodiversity and ecosystems. First, the environmental risk assessment (ERA) fails to consider the full range of risks linked to pesticide use, including risks from transformation products deriving from the degradation of active substances in the environment, cumulative effects, sublethal exposure, chronic toxicity (Storck, Karpouzas, and Martin-Laurent 2017; Schäfer et al. 2019; Sgolastra et al. 2020; Weisner et al. 2021). As a result, harmful molecules can slip through the assessment and enter the environment. Second, the very slow pace for reassessment process results in the continued use of PPP that are largely acknowledged as harmful. As illustrated by Storck, Karpouzas, et Martin-Laurent (2017), it is not unusual to have a 20 to 30 years' time lag

between the development of a new pesticide and the awareness demonstration of its harmfulness by academic studies. This is a long period of time during which the environment and human health are exposed to potential risks associated to these pesticides.

1.2.4.1.3 Economic impact

At economic level, the regulation of PPP approval might indirectly induce effect on **market structure**. Following the implementation of ERA, hazardous substances have been banned from the EU, forcing pesticide manufacturers to develop new classes of active substances. This continuous introduction of new products and bans of old ones has created a pesticide market which is under constant evolution (Storck, Karpouzas, and Martin-Laurent 2017). As more test and data are required for a PPP to be approved, the procedure generates additional costs that affect sectoral competitiveness through increased R&D investments (Chapman 2014), as well as the emergence of new markets, e.g. biocontrol active substances (Robin and Marchand 2019; Chandler et al. 2011). The REFIT evaluation of EU legislation on plant protection products and pesticides residues (European Commission and ECORYS 2018) estimated at 11,7% the increase in overall costs of development of a new plant protection product resulting from the increased regulatory requirements between the periods 2005-08 and 2010-14. They further acknowledged that it is particularly difficult for smaller companies to meet the requirements of the legislation and to bear the associated **costs** of research and development. The data requirements and procedures induced by the legislation are of particular concern for SMEs and has led to a negative trend in the number of micro and small enterprises and the level of **employment** in these enterprises (European Commission and ECORYS 2018). This is in line with Drogué et DeMaria (2012) who directly associate with MRL standard setting higher costs due to stricter regulations to comply with.

While some argues that the EU pesticide legislation would reduce the availability of PPPs in Europe (Chapman 2014), thereby affecting the competitiveness of EU agriculture, this claim cannot be supported by quantitative evidence (European Commission and ECORYS 2018).

In 2019, the European Institutions adopted Regulation (EU) 2019/1381, effective in March 2021, to increase the transparency and sustainability of the EU risk assessment in the food chain. This new regulation is however anticipated to have some negative economic impact related to **knowledge capital spillover** and **employment** (Chatzopoulou, Eriksson, and Eriksson 2020). The significant focus of the regulation on risk communication through, among others, automatic publication of all studies and stakeholders' consultations, while important, raises concerns in the industry concerning confidentiality and property rights with implications on research and innovation in the

sector. Furthermore, early publication of information could jeopardize innovation and jobs creation as the industry would be reluctant to continue investing in EU countries (Chatzopoulou, Eriksson, and Eriksson 2020).

1.2.4.2 Market & post-market risk management – Controls and Labelling

The management of risks related to pesticides at market and post-market level is instrumentalized through controls and labelling requirements.

Controls of pesticides levels in or on food and feed of plant and animal origin is an important instrument to ensure MRLs are respected and to guarantee consumers' health. However, the scope of our literature review did not allow us to find articles on the specific impact of controls and surveillance tools for MRL within the EU. The following paragraph focuses on the social impact of labelling (no environmental and economic impacts could be retrieved from the assessed literature).

1.2.4.2.1 Social impact

Regulation (EC) 1107/2009, which governs the placing of plant protection products on the market in the European Union, includes specific provisions regarding packaging, labelling, and advertising. These provisions aim to ensure that users are able to safely and effectively use plant protection products, while also minimizing potential risks to human health and the environment. These provisions provide positive social outcomes as regards consumer/user rights. Harmonized obligatory instructions for operators to wear personal protective equipment and other harmonized risk mitigation measures contribute to a safe use of PPP and to more **transparency** and comprehensibility (Lichtenberg et al. 2015).

1.2.4.3 Implementing tools – National Action Plans

The EU's Sustainable Use of Pesticides Directive (2009/128/EC) requires Member States to develop NAPs to promote the use of Integrated Pest Management (IPM) and reduce the risks associated with pesticide use. While the EU provides guidance on the content and format of NAPs, the development and implementation of NAPs is left to the discretion of each Member State. The EU relies on a cooperative and participatory approach to implement NAPs, where stakeholders are involved in the development and implementation of measures to promote the use of IPM. In 2021, Helepciuc et Todor (2022) stressed the minimal effect brought by the Sustainable Use Directive in homogenizing different states' approaches to develop their NAPs. Indeed, the Sustainable Use Directive defined an overarching objective (the sustainable use of pesticides), three goals (risk reduction, promotion of IPM, low-risk alternatives to pesticides), and a set of compulsory action areas. Still, it proposed no quantifiable means to assess progress and no mandatory targets. Instead, each EU Member State was supposed to propose measurable objectives, targets, measures, and indicators that

would allow for verifying its NAP implementation. As a result, significant differences exist among countries' NAPs (Helepciuc and Todor 2021). Without an EU-level coherent methodology for creating the NAPs and a set of comparable indicators to assess progress on each measure proposed, it is very challenging to evaluate the impact of the Sustainable Use Directive and its NAP instrument.

1.2.4.3.1 Social and environmental impacts

In 2019, the European Commission published its first calculation of two Harmonized Risk Indicators (HRI). HRI 1 is a measure of the acute toxicity of a pesticide to humans. It consists of measuring the use and risk of pesticides based on pesticide sales data. HRI 2 is a measure of the chronic toxicity of a pesticide to humans, which is calculated based on the number of emergency authorizations reported to the Commission by Member States. In this first calculation, data showed a decrease of 17% in HRI 1 in the use and risk of pesticides but a 56% increase in HRI 2 in the evolution of emergency authorization. Helepciuc et Todor (2022) consider these results as mild progress raising important questions about the overall capacity of the EU MSs to achieve notable success in decreasing the risks to **public health** and the **environment** posed by synthetic pesticides.

Moreover, the methodology underpinning these indicators has been criticized by key actors, such as the European Court of Auditors (European Court of Auditors 2020) and the German Environment Agency (Bär et al. 2022).

1.2.4.3.2 Economic impact

The NAP can have positive economic impact by fostering **knowledge capital** spillover, as the requirement for Member States to conduct crop protection activity using a system of Integrated Pest Management is likely to foster more investment in IPM research and development (Lamichhane, Messéan, and Ricci 2019; Hillocks 2012). The transposition of the NAP requirement into French law, for instance, resulted in the development of the Ecophyto plan, which has translated into dynamic and significant advances made by research. This dynamism is expected to produce a corpus of scientific knowledge and technical innovations which can contribute to the expected transition toward a low-input crop protection system (Lamichhane, Messéan, and Ricci 2019).

1.2.4.4 *Synthesis of EU pesticide policies' impacts on social, environmental and economic factors*

Table 6 provides a synthesis of the impacts of EU pesticide policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 6. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU pesticide policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Ex-ante risk assessment	(+) Public health (-) (/) Transparency	(+) Biodiversity (-) (/) Toxicity	(+) (-) Compliance costs (-) Employment (/) Market structure
Market & post-market risk management	(+) Transparency (-) (/)	(+) (-) (/)	(+) (-) (/)
Implementing tools	(+) (-) (/) Public health	(+) (-) (/) Undissociated	(+) Knowledge capital (-) (/)

1.3 Genetically Modified Organisms

As a foreword, it should be noted that the regulation of Genetically Modified Organisms (GMOs) and associated issues are significantly impacted by public opinion, which remains largely unfavorable in the EU. Assessing the impact of policies on GMO externalities is further complicated by the existence of a wide range of studies and opinions on the subject.

1.3.1 Introduction

Since commercially introduced to farmers in 1996, genetically modified (GM) crops have generated a great deal of controversy, with major debates polarizing the scientific community, consumers, farmers, and policymakers (Maghari and Ardekani 2011; Garcia-Yi et al. 2014; Tsatsakis et al. 2017; Agarwal and Singh 2020). Various socio-economic and environmental motivations are given either in favor or in opposition to this agricultural biotechnology.

At socio-economic level, GM crops are considered by its defenders as a solution to ensure food security in an ever-growing world (Raybould and Poppy 2012). They are expected to bring positive changes in yield, either through increased plant productivity or through increased resistance to stresses, thereby improving economic returns for farmers (Raybould and Poppy 2012; Garcia-Yi et al. 2014; Tsatsakis et al. 2017). They are also perceived as beneficial for health as they are expected to bring additional nutritional quality to crops (Raybould and Poppy 2012).

Various studies point however to other risks for human health, due to associated food allergies, antibiotic resistance or nutritional changes (Maghari and Ardekani 2011). GM crops are also accused of negative economic impact, due to their different price premium (Munro 2008). As such, non-GM fields infiltrated with a GM variety will not reap the same price premium as crops guaranteed GM free. Besides, important concern is raised about Intellectual Property Rights, as GM crops are patented by Agri-business companies, which could lead to monopolization of the global agricultural food and controlling distribution of the world food supply (Maghari and Ardekani 2011).

At environmental level, GM crops are defended as being highly beneficial for the environment due to their potential to face the growing scarcity of environmental resources and to reduce the use of chemical inputs (Maghari and Ardekani 2011; Garcia-Yi et al. 2014). They are further acknowledged for their contribution to virtuous farming practices allowing for reduced soil erosion, runoff, and greenhouse gas emissions (Garcia-Yi et al. 2014).

On the other hand, this technology is accused of bringing grave risks of destructive and irreversible genetic pollution (Maghari and Ardekani 2011). In particular, concern is raised on the emergence of superweeds and superpests and the decline in biodiversity

that are associated with GM crops. Furthermore, the transfer of GM traits to crops might have undesired ecological consequences by giving them a selective advantage over wild plants in natural ecosystems (Munro 2008; Ehlers 2011). Such studies therefore urge to proceed with caution when dealing with GMOs (Maghari and Ardekani 2011).

It should be noted that the 2012-2015 EU-funded GMO Risk Assessment and Communication of Evidence (GRACE) project aimed, among others, at assessing the overall debate on GM safety assessment, concluded that no effects of insect resistant GM crops (tested with Bt maize, which is authorized in the EU) were documented on non-target organism populations, such as beetles and butterflies or to soil microorganisms, when compared to natural maize (Grace project 2016).

The debate surrounding the potential socioeconomic and environmental impacts of GM crops, food, and feed remains a contentious issue, and despite efforts to address concerns and objectify opposition, arguments and disagreements persist.

To deal with the perceived potential risks and uncertainties of GM crops, food and feed, the EU adopted a precautionary approach. Two main regulations were passed with the objectives to protect human health and the environment when (a) carrying out the deliberate release into the environment of genetically modified organisms for any other purposes than placing on the market within the Community (Directive 2001/18/EC 2001), and (b) placing on the market genetically modified organisms as or in products within the Community (Regulation (EC) 1829/2003 2003).

1.3.2 Description of GMO-related policies at EU-level

The regulation of GMOs gained attention in the EU in the late 1980s. The first Council Directive 90/220/EEC covered their deliberate release into the environment and market introduction. Following a number of food crises and the requirement to realign with World Trade Organization law, several Member States asked for a revision of the approval process and requirements for placing GMOs on the market by the end of the 1990s (D. Eriksson et al. 2020). In response to this, a new legal framework repealed Council Directive 90/220/EEC with Directive 2001/18/EC on the deliberate release into the environment of GMOs. Since its publication, the Directive has been amended and complemented several times to include, among others:

In 2003	Regulation (EC) 1829/2003	Specifications for GM food and feed (GMF)
	Regulations (EC) 1830/2003 and (EC) 65/2004	Labelling and traceability requirements

	Regulation (EC) 1946/2003	Rules on transboundary movements
	Regulations (EC) 178/2002 and (EC) 1829/2003	A centralized authorization procedure for GMOs
	Commission Recommendation of 23 July 2003	Coexistence recommendations
In 2004	Directive 2004/35/C	A liability regime for environmental and biodiversity damages
In 2009	Directive 2009/41/EC	Provisions on contained use of genetically modified micro-organisms
In 2010	Commission Recommendation of 13 July 2010	A second version of recommendation for coexistence measures
In 2015	Directive (EU) 2015/412	Provisions to allow Member States to restrict or ban GMO cultivation in their territory
In 2018	Directive (EU) 2018/350	An update of the environmental risk assessment process
In 2019	Regulation (EU) 2019/1381	Transparency and sustainability of the EU risk assessment in the food chain

These main pieces of legislation are supplemented by various implementing rules and by recommendations and guidelines on more specific aspects, resulting in a large number of GM-related policies in the EU. The present evaluation focuses on policies considered as the main, overarching GM legislations affecting food systems. They are presented in Table 7, by chronological order.

Table 7. List of main EU policies enabling the internalization of externalities linked to GMO in food systems

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Directive 2001/18/EC	On the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC	Deliberate release	April 2001	October 2002	Repealing Council Directive 90/220/EEC
Regulation (EC) 1829/2003	On genetically modified food and feed	GM Food & Feed	November 2003	April 2004	
Regulations (EC) 1830/2003	Concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC	Traceability and labelling	November 2003	April 2004	
Regulation (EC) 1946/2003	On transboundary movements of genetically modified organisms	Transboundary movements	November 2003		

Following the establishment of this framework on GMOs, risk assessment and risk management are considered largely harmonized at the EU level. However, the institutional environment for planting GM crops in Europe is heterogeneous across Member States (Beckmann, Soregaroli, and Wessler 2006; D. Eriksson et al. 2020). While, in 2003, the European Commission stated that "no form of agriculture, be it conventional, organic or agriculture using genetically modified organism, should be excluded in the European Union", it decided to follow the principle of subsidiarity, meaning that Member States can adopt their own rules governing coexistence (European Commission 2003). From this principle results many divergences in the management of GMOs across European countries. Additionally, under Directive (EU) 2015/412, since 2015 a Member State may provisionally restrict or prohibit the use

and/or sale of a particular GMO on their territory if new findings indicating potential environmental or health risks of the organism appear.

1.3.2.1 Directive 2001/18/EC – Deliberate release

Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms is the text of reference regulating the approval process for the cultivation and use of GM crops in the Member States. Its objective is to establish a comprehensive framework for the safe use and release of genetically modified organisms into the environment within the European Union (Directive 2001/18/EC 2001).

The directive requires that any GMO intended for release into the environment undergoes a thorough risk assessment, following a prescribed methodology, taking into account potential risks to human and animal health and the environment. In addition, the directive establishes a system of notification and authorization for the release of GMOs, which includes a consultation process with the public and relevant stakeholders. It also requires that appropriate monitoring and post-market surveillance of GMOs be carried out to ensure ongoing safety.

1.3.2.2 Regulation (EC) 1829/2003 – GM food & feed

Regulation (EC) 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed is a regulation that specifically deals with the authorization and labelling of genetically modified food and feed products in the EU. It provides a harmonized and centralized procedure for the scientific assessment and authorization of GM food and feed. Furthermore, the regulation requires labelling of all GM food and feed, which contain or consist of GMOs or are produced from or contain ingredients produced from GMOs.

Related policies:

- Commission Regulation (EU) No 619/2011 of 24 June 2011 laying down the methods of sampling and analysis for the official control of feed as regards presence of genetically modified material for which an authorization procedure is pending or the authorization of which has expired.

1.3.2.3 Regulations (EC) 1830/2003 – Traceability & labelling

The traceability and labelling regulation provides a harmonized EU system for identifying GM products throughout the supply chain with the objective of facilitating accurate labelling in accordance with Regulation (EC) 1829/2003 (UK Food Standards Agency 2003). This regulation mandates that food and feed products containing GMOs (with a threshold of 0.9%) must be labelled with the words ‘genetically modified’ or ‘produced from genetically modified (name of the organism)’ (Regulation (EC) 1830/2003 2003). It

is worth noting that, while the use of GM animal feed is regulated under EU law, the EU does not require products derived from animals fed with GM feed to be labeled as such.

1.3.2.4 Regulation (EC) 1946/2003 – Transboundary movements

Regulation (EC). 1946/2003, which entered into force in November 2003, applies to the transboundary movements of all GMOs that may have adverse effects on the conservation and sustainable use of biological diversity, also taking into account risks to human health.

1.3.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

In the European Union, strong public opposition to GMOs contributed to the development of one of the strictest GMOs legislations worldwide. In order to meet societal concerns relating to the safety of GM crops, the EU adopted a precautionary principle position, with rigorous command-and-control (C&C) measures requiring robust ex-ante risk assessment, as well as ex-post risk management at production level (co-existence measures) and at market and post-market level (monitoring, traceability and labelling).

In the following evaluation, we evaluate the effectiveness of two main instruments related to policies compiled in Table 7 in dealing with externalities of GMOs:

1. ex-ante risk assessment and
2. market and post-market risk management (monitoring, and traceability and labelling)

Risk management at production level, established through co-existence measures for the cultivation of GM crops, are not assessed here. As the European Commission follows the subsidiarity principle for the implementation of legal coexistence frames, such measures are handled by Member States. As a result, there are strong discrepancies between MSs, with some having no coexistence measures at all, and others having ex-ante measures (isolation distance) and/or ex-post liability measures (Devos et al. 2009). Co-existence is therefore considered out of scope in the assessment of EU-wide impact of regulations on externalities.

Table 8 lists the main instruments used in GMO regulations, with references to the group of actors primarily targeted by the instrument, its ultimate beneficiaries, and the type of externalities addressed. When a type of externality is not fully detailed in the literature, the mention “undissociated” is used.

Table 8. List of policy instruments used in the main EU policies regulating GMO in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
C&C Ex-ante risk assessment	GM crops, food and feed risk assessment	Directive 2001/18/EC; Regulation (EC) 1829/2003	Public authorities	Society at large	Human health; Animal health	Undissociated
C&C Market & post-market risk management	Monitoring & Surveillance	Directive 2001/18/EC; Regulation (EC) 1829/2003	Agro-industry; Farmers	Society at large	Human health; Animal health	Undissociated
	Traceability & labelling	Regulation (EC) 1829/2003; Regulation (EC) 1830/2003; Regulation (EC) 1946/2003	Agro-industry; Farmers	Consumer	Consumer right	

The mention “undissociated” is used to report an impact that is not fully detailed in the literature.

1.3.3.1 Ex-ante risk assessment (GM crops, food and feed) – IOE mechanism

The core of the GMO legislation, based on regulation 2001/18/EC, is an approval process consisting of a pre-release authorization (Christiansen, Andersen, and Kappel 2019). A GMO can be authorized either for cultivation on EU territory, or it can be authorized for use in food and feed that is sold on the European market. The process begins with a comprehensive risk assessment conducted by the applicant, who is typically the developer or producer of the GMO. The applicant must provide scientific data and studies to assess the potential risks associated with GMO, including its potential effects on human health, animal health, and the environment.

The ex-ante risk assessment instrument therefore aims to reduce the social and environmental externalities caused by the use of GMOs by requiring manufacturers and importers to release products that comply with strict standards, thus minimizing the subsequent impacts of GMOs at farm-level.

1.3.3.2 *Market & post-market risk management – IOE mechanism*

1.3.3.2.1 *Monitoring & Surveillance*

Monitoring and surveilling compliance with GMO requirements is an ex-post measure that allows for the management of risks for human health, animal health, and the environment after the release of GMOs. As such, this instrument supports the minimization of social and environmental externalities associated with GMOs by (1) encouraging an effective enforcement of EU standards and (2) identifying any non-compliance or infringements and taking action to limit their consequences on public and environmental health.

1.3.3.2.2 *Traceability & labelling*

Labelling is an instrument used in agri-food systems to provide accurate information to producers and consumers. By ensuring the availability and transparency of information, labelling allows for freedom of choice, as users can make informed decisions about the products they purchase based on their values and preferences. This instrument is supported by the existence of a traceability mechanism to monitor movements of products along the value chain.

1.3.4 *Evaluation of the impact of the policies instruments on the internalization of externalities*

1.3.4.1 *Ex-ante risk assessment – GM crops, food and feed*

The EU authorization procedure is considered quite burdensome and generates lengthy delays in the authorization process, thereby hindering widespread adoption of genetically modified crops, food and feed (Graff, Hochman, and Zilberman 2009; Smith 2011; Park et al. 2011; Raybould and Poppy 2012; Smart, Blum, and Wesseler 2015; Christiansen, Andersen, and Kappel 2019; Wesseler 2019). As a result, only one GMO is currently authorized for cultivation in the EU (Monsanto's MON810 pest resistant maize), though no application for authorization has ever been rejected by the EC (Smart, Blum, and Wesseler 2015; Christiansen, Andersen, and Kappel 2019). For food and feed use, a larger number of GMOs (around 90) are authorized (European Commission 2023a). Christiansen, Andersen, et Kappel (2019) explain the difference between the number of authorizations for cultivation and for food and feed by political factors, due to the reduced opposition to food and feed use compared to cultivation, and by the fact that the environmental risk assessment for food and feed use is less extensive than for cultivation.

In the U.S., by comparison, the authorities have adopted a quite permissive approval policy for GM food products, resulting in a much larger number of crops approved for cultivation. Various reasons are advanced to explain such discrepancy between the EU and other regions of the world, including strong negative consumer perception and

citizens' mistrust of the integrity of regulatory decisions, continuous scientific uncertainty arising from the lack of consensus, political uncertainty due to overlaps between regulations (i.e. pesticide and GMOs regulations), or powerful political and non-political opposition forces (Graff, Hochman, and Zilberman 2009; Ehlers 2011; Raybould and Poppy 2012). Furthermore, heterogeneity across Member States' legislations on GM crops cultivation is considered to have been detrimental to the uptake of GMOs (Smith 2011). Indeed, importers and cultivators must balance anti-GMO legislation, such as that in Hungary, against pro-GMO legislation in other European countries, such as Romania (Smith 2011).

In an attempt to improve the authorization process, an amendment to regulation 2001/18/EC was introduced by the EC in 2015 (Directive (EU) 2015/412) to permit individual MSs to opt-out of the authorization of the cultivation of GMOs on their territory for reasons other than safety. In effect, this means that individual MSs are allowed to ban the cultivation of a given GMO even if it has been judged safe by EFSA. Christiansen, Andersen, et Kappel (2019) highlight in particular the de-harmonizing impact of that amendment on EU GMO regulation and the associated shift of responsibility from the EU to Member States.

Overall, by – de facto – acting as a ban for GMOs cultivation in EU Member States, the ex-ante risk assessment instrument set in place in Directive 2001/18/EC **prevents the widespread emergence of externalities** directly associated with the cultivation of GM crops. The limited opportunity for GMOs adoption in EU generates both direct and indirect economic impacts for European GMOs stakeholders that are set aside from the worldwide GM market. For instance, Park et al. (2011) estimate that delays to cultivation approvals in the EU directly costs its farmers between €443 million and €929 million each year⁴. Besides, divergences among Member States' perception and management of the risks associated with GM crops, feed and food, results in a heterogenous regulatory environment across EU, which has a number of socio-economic and environmental impacts.

1.3.4.1.1 Economic impact

At economic level, the decentralized heterogenous approaches to regulate the use of GM crops, food and feed has an **effect on the structure of the EU agricultural market**, since the GM goods produced in a country can no longer **freely move** in the market (Smith 2011). Besides, it can generate differences in the **competitiveness** of European producers (Raybould and Poppy 2012; M. Eriksson et al. 2018). For instance, in Sweden where compound feed is mostly manufactured from non-GM soy, the cost of animal production is reported to be 15% higher than in other EU member states (M. Eriksson et

⁴ This study received funding from Monsanto.

al. 2018). On the other extreme, EU member states that rely on GM soy for compound feed, such as Belgium, Netherlands, Portugal and Spain, have lower costs of production, which makes their animal farmers more competitive (M. Eriksson et al. 2018). Finally, the divergence in approaches to regulation of GMOs among countries and the EU zero tolerance policy toward non-approved GMO imports are considered to inhibit **trade** (Philippidis 2010; Raybould and Poppy 2012; Smart, Blum, and Wesseler 2015; Pavleska and Kerr 2020). By disrupting imports, this trade effect could in turn compromise the competitiveness of the EU livestock sector, which would jeopardize agricultural incomes and **employment** (Raybould and Poppy 2012; Smart, Blum, and Wesseler 2015).

In addition to its direct effects on the European agricultural market, the strict and heterogenous ex-ante GMO regulation in the EU has economic consequences for biotechnology industries. The highly complex risks assessment demanded by the EU results in high **costs** for companies that must comply with this requirement (Maghari and Ardekani 2011; Ricroch, Boisson, and Kuntz 2015; Smart, Blum, and Wesseler 2015; Wesseler 2019). Besides, the risk assessment procedure has faced criticism for not being based on sound scientific knowledge, but instead for responding to political agendas (Ricroch, Boisson, and Kuntz 2015; Christiansen, Andersen, and Kappel 2019; Wesseler 2019). There has therefore been calls to simplify this procedure, which would result in lower transaction costs for private companies.

These transaction costs incurred by the authorization procedure, combined with its complexity, its time-consuming character and the highly uncertain outcome, may discourage investments in the GM technology by the private sector (Graff, Hochman, and Zilberman 2009; Maghari and Ardekani 2011; Raybould and Poppy 2012; Zepeda, Wesseler, and Smyth 2013; Smart, Blum, and Wesseler 2015; Wesseler 2019). This disincentive for investing in R&D represents a negative **knowledge capital spillover** leading to reduced innovation. These transaction costs further impact the **structure of the biotechnology market**, due to the resulting high costs of entry, which have led individuals and companies to either exit the industry or relocate their research and development activities (Graff, Hochman, and Zilberman 2009; Smart, Blum, and Wesseler 2015; Wesseler 2019). In addition to directly compromising small and medium sized companies, those costs are reported to support industry concentration within large companies, as illustrated by the recent mergers of Syngenta and China National Chemical Corporation (ChemChina), DOW and Dupont, and Bayer and Monsanto, which are expected to reduce R&D and operational costs (Wesseler 2019). These effects on the market in turn reduce the development of **human capital**, expertise, investment and employment opportunities and further degrades innovative capacity (Graff, Hochman, and Zilberman 2009; Raybould and Poppy 2012; Smart, Blum, and Wesseler 2015; Wesseler 2019).

A final economic consideration pertains to the transaction costs incurred to public authorities for complying with the regulation. Raybould et Poppy (2012) consider that millions of euros are needed every year to maintain the EU regulatory bureaucracy for GM crops, including parts of EFSA, competent authorities in member states and public research into human and environmental risks. They further point to the potential waste of time and money this would represent, should GM crops be considered as politically unacceptable in the EU, regardless of scientific evidence.

According to the view of Raybould et Poppy (2012), if this money has any chance of being well spent, there must be a policy that GM crops can be grown in the EU if they meet certain criteria, and that scientific analysis of the risks posed by cultivation will play some part in the decision for particular products. If cultivation of GM crops is politically unacceptable in the EU, then scientific analysis of the risks of GM crops will have no effect on decision-making and is thus considered a waste of time and money.

1.3.4.1.2 Social impact

At social level, the amendment allowing EU member states to restrict or prohibit the cultivation of genetically modified plants on their territory is thought to complicate **information for consumers** (Smith 2011). This complexified information sharing is related to the need for producers, manufacturers, and corporations to conform to varying standards, resulting in potentially confusing or conflicting information for consumers. Besides, having separate markets, both pro-GM and anti-GM affects the **availability of choices** faced by producers and consumers (Desquilbet and Poret 2014). Heterogeneity in national markets therefore means heterogeneity in the choice available to these producers and consumers from one country to another.

The time taken for a GM crop's application successfully passing through the political step of the overall authorization process is considered by some authors of socio-economic importance as the quicker it takes, the sooner society can benefit from using it (Graff, Hochman, and Zilberman 2009; Smart, Blum, and Wessler 2015; Wessler 2019). The delay imposed by the European regulatory framework is therefore sometimes considered to represent a **missed opportunity of societal benefit**.

1.3.4.1.3 Environmental impact

At environmental level, some authors report that the complicated risk assessment procedures, which acts as disincentive for companies to invest in further research and development, leads to slower innovation, ultimately affecting the **benefits** for consumers and the **environment** (Graff, Hochman, and Zilberman 2009; Wessler 2019). Others, like Chvátalová (2019), rather argue for the pertinence of the safety assessment procedure of GM crops in the EU to successively evaluate **ecological risks**, such as biosafety of bee pollinators.

1.3.4.2 Market & post-market risk management – Monitoring & Surveillance

Applications for placing on the market of genetically modified organisms for import, food, feed and processing under Directive 2001/18/EC and Regulation (EC) 1829/2003, have to include a post-market monitoring plan. This monitoring plan includes the need for case-specific monitoring, designed to monitor known adverse effects identified in the environmental risk assessment, and a general surveillance system, designed to identify the occurrence of unanticipated adverse effects on human and animal health or the environment. In addition to its role in monitoring adverse effects, the monitoring system is required to ensure that GMO labelling and traceability requirements of Regulation (EC) 1830/2003 (EU, 2003b) are met (Kleter et al. 2018).

The surveillance system is crucial for the proper regulation of GMOs, as it helps to ensure the safety of GMOs and minimize any potential risks associated with their use. However, because of the very strict GMOs regulatory environment in the EU, there is very limited data available to assess the long-term impacts of GMOs on social and environmental factors. The capacity to design effective surveillance systems is therefore doubted considering the shortage of evidence for adverse impacts related to GMOs and the lack of a specific test to confirm these effects (Wilhelm and Schiemann 2007; Vince et al. 2018).

Besides the lack of data weakening the design of an effective surveillance system, the harmonization of that system represents another challenge. As Directive 2001/18/EC on the release of GMOs proposes to use existing surveillance networks for the monitoring of environmental impacts of GM plant cultivation, this raises the issue of standardization, since European and national institutions are poorly harmonized concerning their scopes, tasks and methods (Wilhelm and Schiemann 2007).

Despite these concerns, the post-market monitoring plan required in Directive 2001/18/EC should encourage the **knowledge spillovers** between national GMO monitoring stakeholders, and with other sectors (Wilhelm and Schiemann 2007). This exchange of information and knowledge can help to improve the safety assessment and monitoring of GMOs, particularly as new products and technologies are developed. It can also promote greater public confidence in the safety of GMOs, which is important for the acceptance of these products.

1.3.4.3 Market & post-market risk management – Traceability & labelling

1.3.4.3.1 Social impact

Traceability and labelling for GMOs are both practical tools in support of the post-marketing monitoring plan. Traceability provides a safety net by facilitating both the withdrawal of products where unforeseen adverse effects on human or animal health

or the environment have been observed, as well as the targeting of monitoring to examine potential effects on the environment (Kleter et al. 2018). It further enables the control of labelling claims, which ensure the availability of accurate information to producers and consumers as a mean to ensure **freedom of choice** (Vaasen, Gathmann, and Bartsch 2006; Maghari and Ardekani 2011; Desquilbet and Poret 2014; Kleter et al. 2018). This labelling requirement has been made mandatory in the EU In light of the considerable and lasting societal opposition to GMOs (Desquilbet and Poret 2014).

In practice, ensuring traceability and labelling all along the food chain is a huge challenge. In their evaluation of the traceability of GM maize grown in Spain, Kleter et al. (2018) confirm that data on the specific GM product present in feed is rapidly lost downstream in the subsequent stages of mixing and processing feed ingredients from various sources. While a large share of feed materials is labelled as containing GM materials, there seems to be a global lack of comprehensive, **publicly accessible data** that provides detailed information regarding the GM vs. non-GMO origin of feed materials at the final consumer level.

As a final consideration of the social impact of traceability and labelling, it should be noted that some authors criticize the overall relevance of mandatory risk-based GMO labels, similar to those required in the EU, as it is not perceived as providing valuable information to consumers (Gruère 2006; Premanandh 2011; Smyth, Kerr, and Phillips 2017; Christiansen, Andersen, and Kappel 2019). Christiansen, Andersen, and Kappel (2019) argue for instance that such labels are senseless, since they do not pick out a type of food that is particularly risky. They base this opinion on the absence of observation of adverse effects after more than 20 years of widespread use of safety-approved GMOs. They conclude that the desire to avoid GMOs does not constitute a sufficiently important interest to consumers to justify mandatory labelling. What is more, if there is a demand for GMO-free products, they expect farmers and retailers to voluntarily label their products in order to meet that demand specifically.

In their study on the impact of labelling on international trade, Smyth, Kerr, and Phillips (2017) suggest that, given the cost of segregating GM from non-GM goods, firms might seek a soft option for GM labelling, using the vague 'may contain' GMOs claim. They argue that such a reaction was already observed in the case of allergens such as peanuts when strict labelling and liability regulatory regimes were put in place. As a result, the labelling information is considered to be of little use to consumers.

1.3.4.3.2 Environmental impact

As a tool providing data for GM crop monitoring purposes, traceability and labelling requirements are considered beneficial in ensuring the overall environmental safety (Vaasen, Gathmann, and Bartsch 2006).

1.3.4.3.3 Economic impact

Traceability and labelling instruments have been criticized for their economic implications. They generate higher **transaction costs** to ensure compliance, as the identification and quantification of GM material in products inevitably entails additional costs for the industry (Gruère 2006; Devos et al. 2009; Smith 2011; Maghari and Ardekani 2011; Smyth, Kerr, and Phillips 2017). These transaction costs may be further reinforced by the heterogeneity existing among national GMO regulations that may lead to the need for case-specific adaptation of the traceability and labelling (Smith 2011). Furthermore, there is concern that obligatory labelling, and its related cost, would hold back innovation in the biotechnology industry, creating negative **knowledge capital spillover** (Maghari and Ardekani 2011).

According to Gruère (2006), the EU labelling regulation actually acted like a market ban. His observations in French supermarkets suggest that the strict regulation pushed processors and retailers to remove GM ingredients to avoid the cost of labelling. He further argues that the EU mandatory labelling policy has created negative **network effects** by obliging exporters of food products to follow a strict traceability program when reaching the EU market. This may heavily influence the decisions of developing countries to introduce GM crops.

1.3.4.4 Synthesis of EU GMO policies' impacts on social, environmental and economic factors

Table 9 provides a synthesis of the impacts of EU GMO policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 9. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU GMO policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Ex-ante risk assessment	(+) (-) Transparency and choice availability (/)	(+) (-) (/) Undissociated	(+) (-) Market structure (-) Employment (-) Costs (-) Knowledge capital spillovers (-) Human capital spillovers (/)
Market & post-market risk management Monitoring and surveillance	(+) (-) (/)	(+) (-) (/)	(+) Knowledge capital spillovers (-) (/)
Market & post-market risk management Traceability & labelling	(+) Freedom of choice (-) Transparency (/)	(+) Undissociated (-) (/)	(+) (-) Compliance costs (-) Knowledge capital spillovers (-) Network effect (/)

Natural resources and ecosystem management

1.4 Fisheries

1.4.1 Introduction

By depleting fish stocks, Illegal, Unreported and Unregulated (IUU) fishing is considered one of the greatest threats to marine ecosystems, undermining efforts to manage fisheries sustainably (Ovetz 2007; European Court of Auditors 2022). Industrial, unregulated fishing has negative consequences for non-targeted species, such as sea turtles, seabirds, marine mammals, and other threatened marine species that are caught, injured, and killed by inappropriate fishing practices. Overall, by destroying both predatory and prey species upon which complex ecosystems rely for survival, fishing bycatch has extensive negative consequences on the whole marine biodiversity (Ovetz 2007).

The annual global scale of IUU fishing is estimated at about 11–26 million tons, determining an economic loss of 10–23.5 billion dollars (D’Amico et al. 2016). This represents a significant cost that is not directly borne by the fishers themselves but imposed on the oceans and society (Ovetz 2007). Despite commitments to end illegal fishing by 2020 under the Sustainable Development Goals framework, unsustainable fishing persists worldwide (European Court of Auditors 2022).

Additional environmental externalities of fisheries include contribution to the emissions of climate warming carbon dioxide gases by industrial vessels (Ovetz 2007). Aquaculture also participates in the environmental degradation associated with food production systems. In particular, it has negative environmental impact through wastes offloads, introduction of alien species, genetic interactions, disease transfer, release of chemicals, use of wild recourses, alterations of coastal habitats and disturbance of wildlife (Grigorakis and Rigos 2011).

Beyond the extensive environmental damage caused to the marine ecosystems, unsustainable fishing practices have considerable negative economic and social consequences for coastal communities (Ovetz 2007). Among these hidden costs, Ovetz (2007) cites the damage to small-scale fishing activities – with related employment effect –, threats to local food security, losses to indigenous island cultures and harm to more lucrative sustainable economic activities such as sportfishing, tourism, whale watching and diving.

Social costs are further exacerbated by consumer safety issues associated with aquaculture practices. They include the generation of antibiotic-resistant

microorganisms, contaminants transferred to humans through food chain and other hazards from consumption of aquacultured items (Grigorakis and Rigos 2011).

The EU is a major global player in fisheries, both in terms of its fishing fleet and as the world’s largest importer of fishery products (European Court of Auditors 2022). As such, its market is at risk of being affected by fisheries products with negative socioeconomic and environmental impacts.

1.4.2 Description of fishery-related policies at EU-level

From net to plate, fishery products can be caught, transshipped, landed, stored, processed, transported and sold along highly complex, globalized supply chains; combating IUU fishing therefore requires a global response (European Court of Auditors 2022). At international level, the United Nations has developed and adopted a range of legally binding instruments, plans of action and voluntary guidelines. At regional level, countries with fishing interests in a given geographical area have organized themselves in Regional Fisheries Management Organizations. The EU is party to all major international instruments and a member of 18 Regional Fisheries Management Organizations and fisheries bodies (European Court of Auditors 2022).

Furthermore, driven by the overexploitation of fish stocks, the increasing complexity of trade flows and the spread of IUU, specific EU policies have been adopted to better manage the fisheries sector (D’Amico et al. 2016). Table 10 provides an overview of these main policies, by chronological order.

Table 10. List of main EU policies enabling the internalization of externalities linked to fisheries in food systems

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Directive 2008/56/EC	Establishing a framework for community action in the field of marine environmental policy	Marine Strategy Framework Directive	Jun 2008	Jul 2010	Directive (EU) 2017/845 amends the MSFD
Regulation (EC) 1005/2008	Establishing a community system to prevent, deter and eliminate illegal, unreported and	Illegal, Unreported and Unregulated fishing	Oct 2008	Jan 2010	Amending Regulations (EEC) No 2847/93, (EC) 1936/2001 and (EC) 601/2004 and repealing Regulations (EC)

	unregulated fishing,				1093/94 and (EC) 1447/1999
Regulation (EC) 1224/2009	Establishing a Union control system for ensuring compliance with the rules of the common fisheries policy	Control	Dec 2009	Jan 2010	Amending Regulations (EC) 847/96, (EC) 2371/2002, (EC) 811/2004, (EC) 768/2005, (EC) 2115/2005, (EC) 2166/2005, (EC) 388/2006, (EC) 509/2007, (EC) 676/2007, (EC) 1098/2007, (EC) 1300/2008, (EC) 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) 1627/94 and (EC) 1966/2006
Regulation (EU) No 1380/2013	On the Common Fisheries Policy	CFP	Dec 2013	Jan 2014	amending Council Regulations (EC) 1954/2003 and (EC) 1224/2009 and repealing Council Regulations (EC) 2371/2002 and (EC) 639/2004 and Council Decision 2004/585/EC

The fisheries policies are currently under review, but at the time of writing they are in force and directly applicable to EU Member States.

1.4.2.1 *Directive 2008/56/EC – Marine Strategy Framework Directive*

Directive 2008/56/EC establishes a framework for community action in the field of marine environmental policy. It is known as the Marine Strategy Framework Directive (MSFD). The MSFD sets out a common European Union approach and objectives for the prevention, protection and conservation of the marine environment in view of the pressures and impacts of damaging human activities, while allowing for its sustainable use, by means of an ecosystem-based approach (EU Monitor 2008). In particular, the MSFD requires MSs to develop strategies to achieve ‘good environmental status’ (GES), as well as programmes to implement and monitor the measures to achieve GES.

1.4.2.2 *Regulation (EC) 1005/2008 – Illegal, Unreported and Unregulated fishing*

The illegal, unreported, and unregulated (IUU) fishing regulation is the main EU instrument for preventing, deterring and eliminating such fishing. It requires Member

States to take action against fishing vessels and EU nationals engaged in illegal fishing activities anywhere in the world (Regulation (EC) 1005/2008 2008). The two most prominent features of this regulation are the catch certification scheme and the carding system (European Court of Auditors 2022). The first aims to ensure the legality of imports and the second identifies ‘third countries’ (non-EU countries) that are not cooperating in the fight against illegal fishing.

1.4.2.3 Regulation (EC) 1224/2009 – Control

The fisheries control regulation focuses on EU fleet activities, establishing an EU-wide control system for ensuring compliance with the CFP; it applies to all fishing activities in EU waters and all those carried out elsewhere by EU vessels (Regulation (EC) 1224/2009 2009).

To reach the objectives of the CFP, the fisheries control regulation contains provision for MSs and fishery operators including monitoring access to waters and resources; controlling the use of fishing opportunities and capacity; ensuring appropriate enforcement measures in the event of infringements; enabling the traceability and control of fisheries products throughout the supply chain. The control and inspection operations are coordinated by the European Fishery Control Agency (EFCA), which also fosters cooperation among Member States in order to improve the implementation of and compliance with the CFP.

Related policies

For the control of third-country fishing vessels operating in EU waters and EU vessels fishing elsewhere:

- Regulation (EU) 2017/2403 of the European Parliament and of the Council of 12 December 2017 on the sustainable management of external fishing fleets, and repealing Council Regulation (EC) 1006/2008

1.4.2.4 Regulation (EU) No 1380/2013 – CFP

The Common Fisheries Policy (CFP) is the primary framework for fisheries management in the EU (Regulation (EU) No 1380/2013 2013). It is a set of rules aimed at managing sustainably European fishing fleets and conserving fish stocks. Initially embedded within the CAP, the CFP started with the same objectives: increase productivity, stabilize markets, provide healthy food, and ensure reasonable prices for consumers (European Commission n.d.; Wakefield 2018). Over time it has gradually become more independent. From its first outlines in 1970, the policy has undergone regular reforms, with the latest iteration adopted at the end of 2013 and enforced since the start of 2014 (Wakefield 2018). It is in the 2002 reform that sustainability was added as a core objective of the CFP, with the main goal of ensuring the long-term viability of the fisheries sector through sustainable exploitation (Wakefield 2018).

Under this CFP, the EU has the sole authority and responsibility for legislating and adopting binding acts on fisheries management within its Member States. Once agreed, Member States must comply with the terms of the CFP. It adopted, in particular, two main pieces of legislations for combating illegal fishing : the illegal, unreported and unregulated fishing regulation (Regulation (EC) 1005/2008 ; mainly concerning imports) and fisheries control regulation (Regulation (EC) 1224/2009; mainly focusing on compliance by EU fishers) (European Court of Auditors 2022).

The Member States are responsible on their side for implementing key requirements of the common fisheries policy such as inspecting vessels, checking imports and applying sanctions (European Court of Auditors 2022).

Through the CFP, the EU regulates fishing Total Allowable Catches (TACs). These are set for each fish stock annually, or for longer periods, based on scientific advice and management objectives. Each Member State is allocated a pre-determined share of the TACs, known as the relative stability, using a fixed allocation key that is based on historic catches. However, allocations of quotas within the national fishing sector are the responsibility of the individual MS (Nielsen et al. 2019). In that regard, as proposed (but not mandated) by the EC, many MSs have introduced Individual Transferable Quotas (ITQ) management systems.

TACs are addressed each year in specific amending regulations and decisions that take into account the species, fishing region, and the state of the fish stocks.

Related policies

To establish a common market:

- Regulation (EU) No 1379/2013 of the European Parliament and of the Council of 11 December 2013 on the common organisation of the markets in fishery and aquaculture products, amending Council Regulations (EC) 1184/2006 and (EC) 1224/2009 and repealing Council Regulation (EC) 104/2000

To establish a fund through which the EU supports fisheries control:

- Regulation (EU) No 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) 2328/2003, (EC) 861/2006, (EC) 1198/2006 and (EC) 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council (The EMFF primarily focused on supporting the implementation of the CFP).
- Regulation (EU) 2021/1139 of the European Parliament and of the Council of 7 July 2021 establishing the European Maritime, Fisheries and Aquaculture Fund and amending Regulation (EU) 2017/1004 (The EMFAF expands the scope of the EMFF to include not only fisheries and maritime activities but also aquaculture).

To establish technical measures:

- Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) 1967/2006, (EC) 1224/2009 and Regulations (EU) No 1380/2013, (EU) 2016/1139, (EU) 2018/973, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council, and repealing Council Regulations (EC) 894/97, (EC) 850/98, (EC) 2549/2000, (EC) 254/2002, (EC) 812/2004 and (EC) 2187/2005 (lays down technical measures concerning: (a) the taking and landing of marine biological resources; (b) the operation of fishing gear; and (c) the interaction of fishing activities with marine ecosystems)

For controlling aspects:

- Regulation (EU) 2019/473 of the European Parliament and of the Council of 19 March 2019 on the European Fisheries Control Agency. It repealed Council Regulation (EC) 768/2005 of 26 April 2005 establishing a Community Fisheries Control Agency and amending Regulation (EEC) No 2847/93 establishing a control system applicable to the common fisheries policy.

1.4.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

The fisheries policies include several instruments aimed at reducing the negative externalities associated with fisheries. These include both market support and regulatory command-and-control (C&C) measures.

Market-based instruments are implemented to influence fishing behavior and promote sustainable practices through economic incentives and subsidies, as well as markets of rights or permits.

Command-and-control intends to restrict the choices facing actors in order to force compliance with more sustainable fishing practices. They include market & post-market risk management measures to ensure that fishing products entering the EU market are aligned with EU's standards (catch certification scheme, controlling and labelling measures) and implementing tools to compel fishers to adopt sustainable fishing practices (landing obligation and technical measures).

Table 11. List of policy instruments used in the main EU policies regulating fisheries in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
Market support	Fishing quotas	Regulation (EU)1380/2013	Fishing industry	Fisheries		Effect on biodiversity & ecosystem
	Fisheries subsidies	Regulation (EU)1380/2013; Regulation (EU)508/2014 ; Regulation (EU)2021/1139	Fishing industry	Fisheries	Undissociated	Undissociated
C&C Market & post-market risk management	Catch certification scheme (imports)	Regulation (EC)1005/2008	Fishing industry	Fisheries	Transparency	Undissociated
	Controls (EU activities)	Regulation (EC)1224/2009	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
	Labelling	Regulation (EU)1380/2013; Regulation (EU)1379/2013	Fishing industry	Fisheries	Health; Consumer right	Undissociated
C&C Implementing tool	Landing obligations	Regulation (EU)1380/2013	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
	Technical measures (Minimum fish sizes, fishing gear, etc.)	Regulation (EU)1380/2013; Regulation (EU)2019/1241	Fishing industry	Fisheries		Effects on biodiversity & ecosystems

The mention “undissociated” is used to report an impact that is not fully detailed in the literature.

1.4.3.1 Market support – IOE mechanism

1.4.3.1.1 Fishing quotas

Fishing quotas involve the setting of annual Total Allowable Catch (TACs). The TACs are the central instrument of the CFP for achieving stock conservation objectives in the North-East Atlantic (Borges 2021).

TACs represent a use right to the resource, i.e., the right to fish in this case. By transferring ownership of the right to fish to fishers, these actors are motivated to

conserve and manage sustainably the resource (Le Gallic 2003; Libecap 2009), thereby reducing negative externalities of fisheries.

1.4.3.1.2 Fisheries subsidies

The European Union has been providing subsidies and financial support to the fishery sector through various funds through time. Initially funded by the Financial Instrument for Fisheries Guidance (FIFG), the European fisheries policy was then funded by the European Fisheries Fund (EFF) for 2007-2013, replaced by the European Maritime and Fisheries Fund (EMFF) for 2014-2020, and finally the European Maritime, Fisheries and Aquaculture Fund (EMFAF) for the current period 2021-2027. The EMFAF expands the initial scope of funding to include not only fisheries and maritime activities but also aquaculture.

Overall, these subsidies encourage and support the adoption of sustainable fishing practices to reduce overfishing, improve safety and working conditions for fishermen, and support the socioeconomic development of fishing communities. They do so by supporting investments in more selective fishing gear and techniques that minimize the impact on non-target species and habitats and modernization of the fleet for better compliance with environmental regulations. They also promote innovation, research, and knowledge transfer within the fisheries sector. This facilitates the development and adoption of new technologies, practices, and management approaches that can reduce negative externalities.

To give an order of magnitude, under the current funding package for the period 2021 to 2027, the total allocation for fisheries amounts to close to EUR 6 billion. Of this, EUR 5,3 billion is to be allocated to the management of fisheries, aquaculture, and fishing fleets; the rest going to scientific advice, controls and verifications, market intelligence, maritime surveillance, and security (Blanco, Bares, and Ferasso 2022).

1.4.3.2 Market & post-market risk management – IOE mechanism

1.4.3.2.1 Catch certification scheme

The EU introduced in 2010 the catch certification scheme for fish to deal with the problems of illegal, unregulated and unreported fishing which threatens the sustainability of fisheries. This instrument is a way to ensure traceability of fishing activities, and thus transparency, with the aim of halting the introduction in the EU market of fishing products with negative environmental performances.

1.4.3.2.2 Controls

Control and enforcement measures are essential for ensuring compliance with fishing regulations. These measures can involve monitoring fishing activities through vessel tracking systems, inspections at sea and in ports, penalties for non-compliance, and

cooperation among member states for effective enforcement. Through such measures, the regulation promotes accountability and reduces the potential for externalities associated with overfishing, bycatch, or damage to sensitive habitats.

1.4.3.2.3 Labelling

An important component of the EU fisheries policy is the common market organisation regulation (Regulation (EU) No 1379/2013). It sets EU marketing standards for fishery products and consumer information requirements (labelling) to provide consumers with the necessary indications to make an informed choice at the moment of purchase⁵. For example, the label must indicate the commercial designation of the species, the production method, the catch area and the fishing gear. By providing such information, the labels support the selection of safe, healthier and more environmentally sustainable products (Paolacci et al. 2021). Labelling further acts as a tool to prevent frauds and illegal fishing (D'Amico et al. 2016; Esposito and Meloni 2017). A labelling instrument can thus play a key role in encouraging sustainable fisheries operation (Miller and Mariani 2010).

There is however no EU label certifying the sustainability of fishery products (European Court of Auditors 2022; Schebesta 2016).

1.4.3.3 Implementing tools – IOE mechanism

1.4.3.3.1 Landing obligation

Initially, the CFP focused on prescribing measures to control the composition of the landing, i.e., the fishes that are effectively landed by a vessel, rather than the catches, i.e., the fishes caught at sea. As a result, discarding represented a legitimate means for fishers to comply with the regulation by disposing of catch which cannot be legally landed, as well as fish with a low economic value (Condie, Grant, and Catchpole 2013). Discarding has great negative impacts on the environment, however. It increases the mortality of target and non-target species and alters biodiversity and food webs by supplying increased levels of food (discarded dead specimens) to scavenging organisms on the sea floor (Consoli et al. 2017).

In reaction, the 2013 reform of the CFP proposed to reduce these unwanted catches and eliminate discards through an obligation to land all catches. The Landing Obligation essentially modified the quota system from a 'landing' to a 'catch'-base. The LO is only applicable to TAC-regulated species in the Atlantic and to species that have a minimum conservation reference size in the Mediterranean Sea, caught in European waters or by

⁵ Seafood labelling is further regulated under regulations (EU) No.1169/2011 on the provision of food information to consumers. This policy is however out of the scope of this present report.

European fishing vessels (Borges 2021). There are, however, specific exemptions to the obligation to land.

By banning discarding practice, the landing obligation incentivizes the adoption of more selective fishing, thereby reducing negative externalities associated with IUU fishing (Condie, Grant, and Catchpole 2013; Bohman 2019). Indeed, having to retain and land unwanted catches may result in additional costs that lead to a fall in income, generating economic incentives to avoid unwanted catches (Condie, Grant, and Catchpole 2013).

1.4.3.3.2 Technical measures

Technical measures are a set of rules that govern where, when and how fishing can take place, with the goal of ensuring sustainability (Bellido et al. 2020). They are restrictive by nature. These measures can help mitigate the ecosystem impact of fisheries, by improving fishing efficiency, i.e. technology and gear improvements, or by limiting the access of given areas to fisheries (Bellido et al. 2020). These measures thus help reduce bycatch of non-target species and the impact on the ecosystem.

1.4.4 Evaluation of the impact of the policies instruments on the internalization of externalities

Overall, the legal framework adopted by the EU to regulate fishery seems to have two primary objectives: meeting food security objectives (Wakefield 2018) and ensuring that all fishery products sold in the EU are legal (European Court of Auditors 2022). These leave sustainability criteria behind.

In her paper on European protection of fisheries, (Wakefield 2018) notes in particular that, after more than 40 years of CFP, we are still witnessing overfishing, depleted fish stocks, disrupted food chains, ecological damage, and loss of biodiversity. She observes that priority is persistently given to the preferences of the commercial fisheries industry without balancing measures to help reinstate damaged environments or depleted fish resources. As a result, any improvements under the CFP have been from such a low base that they cannot be described as restorative. A reason advanced by the author for the lack of improvement in fisheries is that scientific advice provided to the EU institutions in devising fisheries policy is given insufficient weight, which has severely impeded the achievement of sustainability objectives (Wakefield 2018).

Thus, the instruments used in EU policies are considered insufficiently adapted to deal with the environmental and social externalities of fishing activities.

(Bohman 2019) further highlights the ineffectiveness of a centralized, top-down approach to fisheries management to respond in an adaptive way to regional variations in the EU. He therefore calls for a change in the institutional structures of the fisheries policies to better include stakeholders and have a more decentralized approach.

1.4.4.1 Market regulation – Fishing quotas

As evidenced by Le Gallic in his global evaluation (2003) of governmental implementation of market-based instruments, such as TAC quotas, in fisheries, the move towards such instruments is relatively slow in many countries. He associates with this observation the unsatisfactory performance of the fishing industry in terms of environmental, social and economic outcomes. One obstacle to the use of market-based instruments would consist in the lack of ex-ante information that is necessary to define the Total Allowable Catch level (Le Gallic 2003). The lack of ex-post comprehensive evaluation of the effectiveness of quotas instruments further restricts the use of such market-based instruments.

1.4.4.1.1 Social impact

It is sometimes perceived that the implementation of TACs system is likely to modify the wealth distribution, including through advantaging some participants, usually the most influential ones, over others (Le Gallic 2003; Kane, Ball, and Brehmer 2022), thereby creating **inequities** in the system. Le Gallic (2003) emphasized that such system was likely to push indigenous, traditional and small-scale fishers out of the industry by larger fishing enterprises, squeezing them out of their livelihood. Besides, **transparency** appears to be a controversial issue in the negotiations of TACs (Carpenter et al. 2016).

1.4.4.1.2 Environmental impact

The Total Allowable Catch quotas system seems to have had a limited success in effectively managing fish resources (Kane, Ball, and Brehmer 2022). Under the TAC, fishers may have an interest to discard unwilling catches in order to maximize the value of the quota (Le Gallic 2003). Despite the shift from landing quota to catching quota operationalized through the Landing Obligation, illegal discarding of unwanted catches is still a valuable option for farmers to maximize their economic profits under the TAC system. This is the result of a lack of control and a lack of economic incentives to reduce discarding, which encourage the pursuit of the degradation of marine **biodiversity and ecosystems**.

Furthermore, TACs have been criticized for being persistently set above scientific advice recommending Maximum Sustainable Yield (MSY), which contributes to the continuous overexploitation of fisheries (Carpenter et al. 2016; Borges 2018). The agreed TACs being the result of a negotiations between MSs and the EC, they are usually influenced by national domestic interests, which are based on perceived short-term socioeconomic impacts to the detriment of long-term sustainability goals.

Recently, with the implementation of the Landing Obligation, TACs have been adjusted upward to compensate for the discarding ban. This has led to an increase in fishing

activity, and with it an increase in unwanted catch and discards, precisely in opposition to the LO objectives (Borges 2021).

1.4.4.1.3 Economic impact

As for all management systems, implementing a quota system is associated with higher **cost** for its implementation and operationalization (Le Gallic 2003).

Furthermore, the allocation of quotas might result in the monopolization of ownership in the hand of some actors as a result of market forces (Le Gallic 2003; Kane, Ball, and Brehmer 2022). The quotas system might thus affect **market structure** in an unfair way. As pointed out by (Kane, Ball, and Brehmer 2022), it should be noted that some fisheries experts believe that the concentration of quota shares in the hands of large fishing fleet owners will generate economic **efficiency** gains in the sector.

1.4.4.2 Market regulation – Fishing subsidies

It is of interest to note that the efficiency of European MSs in the use of the funds for the improvement of the fishery sector suffers great regional disparities (Blanco, Bares, and Ferasso 2022). Since efficiency levels seem to correlate to regional characteristics, public policy measures should be articulated in order to take into account this territorial heterogeneity.

1.4.4.2.1 Social and environmental impact

Overall, the establishment of fishing subsidies by governments worldwide is considered to have contributed to obscuring the true costs of large-scale fishing activities (Ovetz 2007; Villasante et al. 2022). Together with the rise of new fishing technologies and a growing demand for fish resources, it has led to a global **depletion of fish stocks** and associated **damage to marine ecosystems** and coastal **communities' livelihoods** (Ovetz 2007; Lam 2012).

1.4.4.2.2 Economic impact

Fishing subsidies are reported to have contributed to fleet overcapacity and the artificial maintenance of the profitability of the fishing industry, thereby distorting the efficient allocation of inputs (Villasante et al. 2022). This effect on the **structure of fishing market** is perceived as socially and economically inefficient and has thus been qualified as harmful (Villasante et al. 2022).

1.4.4.3 Market & post-market risk management – Catch certification scheme (imports)

For imported products, the EU catch certification scheme aims to ensure that flag states certify the legality of all imported fishery products based on their own control and monitoring systems. When comparing with the second (USA) and third (Japan) importers of fishery products, the EU tends to have the most comprehensive catch certification

schemes in terms of scope, information required, and validation and control processes (European Court of Auditors 2022). Despite this effort, significant differences in scope and quality of checks by Member States is reported to weaken the whole system (European Court of Auditors 2022).

1.4.4.3.1 Social impact

In its 2022 special report on EU action to combat illegal fishing, the European Court of Auditors concluded that the control systems in place to combat illegal fishing are partially effective in reducing the risks of illegal fish on EU market by improving **traceability**. However, their effectiveness is reduced by the uneven application of checks and sanctions by Member States.

Concerns have been raised on the generation of **inequities** resulting from the categorical identification and certification against IUU practices (Song et al. 2020). It is considered by Song *et al.* (2020) as a risk to disregard the diversity, legitimacy and sustainability of small-scale fisheries practices. This could result in the creation of unfair burden on small-scale fisheries and countries who depend on them.

1.4.4.3.2 Environmental impact

While the catch certification scheme is relevant in controlling the legality of imported fishery products, it is unsuitable for **environmental performance** control. Indeed, the scheme cannot ensure that the rules applied in non-EU countries are sufficiently stringent to guarantee sustainability (European Court of Auditors 2022).

1.4.4.3.3 Economic impact

The efficiency of control of the catch certification is reduced by the format of the certification, which is still paper-based, and the lack of coordination among Member States (European Court of Auditors 2022). As a result, higher **costs** might arise due to the slower processing time and administrative burden.

The whole scheme might on the other hand foster positive **network effects** by encouraging changes in third countries where control systems are deficient. This mechanism is covered under the carding system of the illegal, unreported and unregulated fishing regulation. Under this system, countries whom control system is not able to efficiently assess the legality of products exported to the EU receive a yellow or red card. Red listed countries, identified as “non-cooperating”, are banned from the European market. Usually, when a country receives notification of deficiencies, it undertakes the necessary reforms and improvements before a formal warning is sent (European Court of Auditors 2022). The European Court of Auditors has thereby evidenced the effectiveness of the carding system in sparking significant reforms in third countries’ national system.

Through that process, the Commission continues to cooperate with countries having insufficient certification schemes and provide technical assistance in order to support the improvement of their national system.

1.4.4.4 Market & post-market risk management – Controls (EU activities)

Member States are responsible for the correct application of the EU fisheries control system by controlling fishing activities within their waters, and those of fishing vessels flying their flag, regardless of location (European Court of Auditors 2022). However, fisheries control and enforcement are rather expensive and difficult to enforce, due to the nature of the fisheries (Bohman 2019). The Commission has identified significant shortcomings in fisheries control systems in some MSs, leading to overfishing and underreporting of catches (European Court of Auditors 2022). In particular, while the majority of serious infringements detected led to sanctions, these varied considerably across MSs for similar infringements, with cases in which sanctions were neither proportionate, nor dissuasive (European Court of Auditors 2022).

1.4.4.4.1 Environmental impact

Similarly to the catch certification, ensuring Member States' compliance with EU rules does not mean that the rules themselves are sufficient to ensure the **sustainability of fish stocks and their habitats** (European Court of Auditors 2022). The European Environment Agency reported in 2019 that the overexploitation of commercial fish and shellfish stocks continues across Europe's seas. Later, the European Court of Auditors emphasized that EU actions to protect the marine environment had resulted in measurable progress in the Atlantic, but that the Mediterranean remained significantly overfished (European Court of Auditors 2022).

1.4.4.4.2 Economic impact

As stated by Bohman (2019), fisheries control and enforcement are typically rather expensive. Implementing such an instrument therefore generates significant **costs** in order to set in place control and surveillance requirements.

To reinforce its control system, the EU invested in fisheries funds providing support to MSs for monitoring, control and enforcement activities. This allowed MSs to invest extensively in control measures, including though the installation and development of control technology, the modernization and purchase of patrol vessels and aircraft, and the development of innovative control techniques (European Court of Auditors 2022). Overall, the implementation of and financial support to the fisheries control system in EU has therefore created **knowledge and infrastructure spillovers**.

1.4.4.5 Market & post-market risk management – Labelling

While labelling is recognized as an important instrument to allow consumers to make an informed purchasing choice, there seems to be a wide disparity in the compliance with labelling requirement among EU MSs (Paolacci et al. 2021). High compliance to labelling in some countries, such as Portugal, was tentatively linked to higher seafood consumption and to a number of other factors, including the level of law enforcement and sociological, as well as cultural factors. Portugal, for instance, has historically a high level of legislative protection of consumers, while the UK on the other hand, where lower labelling compliance was observed, generally displayed a greater political aversion to EU regulation and was subject to several food fraud and quality issues (Paolacci et al. 2021). Differences in regional authorities with varying competences in seafood control might further explain the discrepancies in compliance.

Several studies reported the persistent difficulties of implementation of Regulation (EU) No 1379/2013 on the common market organization and its labelling requirements (D’Amico et al. 2016; Esposito and Meloni 2017; Paolacci et al. 2021). Some called in particular for increased awareness raising among Food Business Operators on the importance of compliance to seafood labelling legislation (Esposito and Meloni 2017).

Failure to comply includes frequent reporting of mislabeling (Miller and Mariani 2010; D’Amico et al. 2016; Esposito and Meloni 2017; Paolacci et al. 2021). This tends to indicate that the EU policies currently in place to regulate seafood labeling have not been adequately implemented and enforced. Additional EU legislative efforts should be redirected to tackle this issue.

Regarding the possibility of an EU Ecolabel, (Schebesta 2016) highlights the need of public regulators to come to terms with the powers of private regulators in that domain. Privates have increasingly taken up the role of standard setters, with for instance retailers drawing up a Code of Conduct or certification scheme owners. In that context, the creation of an EU Ecolabel would be a way of taking back some regulatory power from private to public regulators, which is not perceived as favorable.

1.4.4.5.1 Social impact

The exclusion of prepared and processed products and aquatic invertebrates from the application of the mandatory seafood labelling provisions was identified as a major shortcoming, **depriving consumers of important information** on product origin (D’Amico et al. 2016). In this regard, the EU should require more transparency and full chain traceability for such products, in order to ensure that all seafood marketed within the Member State are safe, legally caught and honestly labeled.

1.4.4.5.2 Environmental impact

At the environmental level, frequent mislabeling has been identified as a serious drawback to efforts made in order to allow **depleted stocks** to recover (Miller and Mariani 2010).

1.4.4.6 Implementing tool – Landing Obligation

The Landing Obligation, if effectively implemented, can serve as a valuable tool for protecting the marine ecosystem by promoting an ecosystem approach and boosting selective fishing (Bohman 2019; Borges 2021). Strict compliance with the discard ban and the provision of strong incentives for fishers to change their fishing practices are however crucial for achieving this outcome. The European Commission (2020a) however noted that compliance with the landing obligation in general still appears to be low.

Because of the lack of control measures and for economic reasons, discarding practices continue with minimal change (Bohman 2019; Borges 2021). An effective implementation of the landing obligation thus requires stringent control and enforcement, and economic incentives to land more of the catch. As it appears, Member States have not adopted the necessary measures to accommodate with the Landing Obligation and significant undocumented discarding of catches remains widespread (European Commission 2020a; Borges 2021)

Furthermore, (Borges 2021) estimates that the Landing Obligation is being widely circumvented by the significant increase in exemptions that have been adopted. This undermines the purpose of the Landing Obligation of reducing unwanted catch (Borges 2021).

1.4.4.6.1 Environmental impact

(Bellido et al. 2017) identified an increase in the illegal marketing of fish below the minimum size as one possible consequence of the Landing Obligation. Besides, since landing unwanted catches is economically not advantageous, fishers might be tempted to unlawfully discard them (Le Gallic 2003; Bohman 2019). These behaviors, instead of reverting the trend, could actually reinforce the **depletion of fish stocks**.

1.4.4.6.2 Economic impact

To avoid any economic loss associated with the landing of untargeted, undervalued, fish species, the industry is encouraged, through the Landing Obligation, to develop selective fishing gears and practices (Feekings et al. 2019). This could favor **knowledge capital spillovers** in the research and development for adapted fishing technologies. A reported drawback, on the other hand, in the generation of knowledge brought by the Landing Obligation is the rise of false reporting (Bohman 2019). To avoid economic losses associated with the landing of untargeted fish species, fishers could resort to illegal discard, which leads to false reporting of data.

1.4.4.7 Implementing tool – Technical measures

1.4.4.7.1 Environmental impact

Using the example of sea bass fishery around England and Wales, Pawson, Pickett, and Smith (2005) showed that, when based on extensive consultation with all users of the sea and on sound science, technical measures introduced to better manage the fishing resources can have positive environmental impacts. In their evaluation, the measures helped increase the protection of juvenile fish and helped **safeguard the stock fished**.

However, Wales, Pawson, Pickett, and Smith (2005) also pointed out that examples of similar success due to technical management measures were hard to come by. Dolman et al. (2021) confirmed that current EU measures on fisheries **protection from bycatch**, with a focus on cetaceans, were inadequate in themselves.

1.4.4.7.2 Economic impact

Bellido et al. (2020) highlight that technical measures do not necessarily ensure fishers' economic gains since they imply **costs** for their implementation. However, it has been recognized that the losses generated in the short and medium term by the implementation of technical measures tend to be compensated by **gains** in the long term.

1.4.4.8 Synthesis of EU fisheries policies' impacts on social, environmental and economic factors

Table 12 provides a synthesis of the impacts of EU fishery policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 12. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU fishery policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Market support Fishing quotas	(+) (-) Equity (-) Transparency (/)	(+) (-) Biodiversity and ecosystems (/)	(+) Efficiency (-) Compliance costs (-) Market structure (/)
Market support Fisheries subsidies	(+) (-) Coastal communities' livelihood (/)	(+) (-) Biodiversity and ecosystems (/)	(+) (-) Market structure (/)
Market & post-market risk management Catch certification scheme	(+) Traceability (-) Equity (/)	(+) Undissociated (-) (/)	(+) Network effect (-) (/)
Market & post-market risk management Controls	(+) (-) (/)	(+) (-) Biodiversity and ecosystems (/)	(+) Knowledge (+) Infrastructure spillover (-) Compliance costs (/)
Market & post-market risk management Labelling	(+) (-) Transparency (/)	(+) (-) Biodiversity and ecosystems (/)	(+) (-) (/)
Implementing tools Landing obligations	(+) (-) (/)	(+) (-) Biodiversity and ecosystems (/)	(+) Knowledge (-) (/)
Implementing tools Technical measures	(+) Biodiversity and ecosystems (-) (/) Biodiversity and ecosystems	(+) (-) (/)	(+) Long-term gains (-) Compliance costs (/)

2 THE SOCIAL SPHERE

Animal health and welfare

2.1 Animal health and welfare

2.1.1 Introduction

The state of health of farmed animals kept for food, as well as their overall well-being can have significant impact on the economy, but also on indirect elements such as human health. With the specialization and industrialization of modern agriculture, livestock production has intensified through increased herd sizes and stocking densities (Vogeler 2019). These processes have increasingly contributed to challenges related to animal health and welfare.

In terms of direct economic impact, animal diseases might adversely affect farm production through higher mortality, reduced output quality, and higher use of inputs such as medication (Bennett 2012). A direct cost is further associated to the detection, diagnosis, prevention, and control of animal diseases. Besides, the emergence of diseases might generate trade restrictions and affect tourism, which can impact rural economies (Bennett 2012; Vetter, Vasa, and Ózsvári 2014).

In addition to the direct effect on farms and regional economies, both livestock disease and its control have a number of indirect effects on third parties. Bennett (2012) identifies three important negative externalities in the context of livestock disease: impacts on the health of other producers' livestock, on human health, and on animal welfare. More difficult to identify and calculate, these indirect effects are however significant and lead to additional costs to society, as resources need to be allocated to diseases control.

2.1.2 Description of animal health and welfare-related policies at EU-level

Given that the economic incentives to improve animal welfare are relatively weak, policymakers have responded by adopting specific farm animal welfare regulations (Vogeler 2019). The development of animal health and welfare regulations in the agriculture sector in Europe has been a gradual process that began in the 1970s. Since then, the European Union has introduced numerous measures to improve animal welfare and safeguard public health and the environment. During the 1990s, the occurrence of Bovine Spongiform Encephalopathy (BSE), commonly known as mad cow disease, gave rise to a severe public health and political crisis relating to food safety in Europe. This crisis in particular triggered an important response, with a set of animal

health and safety measures introduced, and the adoption of a robust precautionary approach to manage the issue (Ferrari 2016; Margalida et al. 2010).

The first concrete legal step aimed at promoting animal welfare dates back to the 1970s with the adoption of Council Directive 74/577/EEC on stunning of animals before slaughter and Council Directive 77/489/EEC of 18 July 1977 on the protection of animals during international transport (Regulation (EC) 1/2005 2018; Vogeler 2019). From the 1980s onwards, specific regulations set minimum standards for the rearing and handling of specific farmed animals (pigs, calves and laying hens first, followed by chickens kept for meat production in 2007) (Vogeler 2019; Vetter, Vasa, and Ózsvári 2014).

In 1993, the Declaration on Animal Welfare was included in the Maastricht Treaty, and in 1997, that declaration became a protocol with legal status. The Treaty of Amsterdam officially recognized animals as sentient beings in 1999, meaning that they can no longer be treated as things, objects or goods (Regulation (EC) 1/2005 2018; Vogeler 2019). The Protocol on Animal Welfare annexed to the Treaty of Amsterdam imposed an obligation on EU institutions and Member States to take account of animal welfare considerations. A decade later, an animal welfare strategy was adopted in 2012 for the period 2012-2015 to improve welfare standards in the EU, with the main purposes of the strategy focused on implementation and enforcement of existing standards, information of all involved actors, and coordination with the common agricultural policy (Regulation (EC) 1/2005 2018). However, to date, the implementation and enforcement of EU animal welfare policies remains a common problem in Member States (Vogeler 2019).

In addition to the development of regulations directly targeted at animal health and welfare, the EU provides financial assistance based on support schemes from the Common Agricultural Policy (CAP). Financial incentives are provided to farmers who take animal-welfare-related measures that go beyond the mandatory standards defined by EU regulations (Vogeler 2019). Nonetheless, out of the total CAP budget, only 1.4% was spent on such measures in the reporting period 2014–2020 and large discrepancies existed between Member States : Germany often goes beyond the EU directives for animal welfare regulations for instance, while in France, regulatory animal welfare policies essentially correspond to the minimum requirements put forward by the European Union (Vogeler 2019).

Today, the animal health and welfare policies of the European Union encompass all facets of farm animal production, starting from the manufacturing and market placing of medicated feed to the animal's life on the farm, during transportation, and at time of slaughter, as well as trade. Table 13 provides an overview of these main policies, by chronological order.

While substantial improvements have been made since the first legal acts on animal health and welfare, such as bringing the very notion of animal welfare into common use and understanding and slowly shifting from simple removal of physical suffering to broader enhancement, many flaws are still associated to EU animal welfare regulations (Buller et al. 2018; Vogeler 2019; European Commission 2020b; Speeckaert 2022). As existing regulations demand mostly minimum standards and do not cover all farmed species, several member states have passed additional national regulations, which has resulted in a large heterogeneity of animal welfare regulations within the European Union (Vogeler 2019).

In their study to support the evaluation of the European Union strategy for the protection and welfare of animals, the Directorate-General for Health and Food Safety recognized that compliance across Member States in some animal welfare legislative areas remains a key challenge. Further, there is increased citizen demand for information on these topics, however, the Union's strategy for animal welfare has failed to improve the provision of adequate information to consumers (European Commission 2020b).

Besides, welfare regulations are still considered to be dominated by the intensive farming systems that are driven by market-based policies (Speeckaert 2022). Increasing recognition of the integrated aspects of human health, animal health, and the environment is, however, contributing to the emergence of a "One Health" approach. As such, more recent regulations such as the Animal Health Law (Regulation (EU) 2016/429) emphasize the importance of collaboration between human health, animal health, and environmental sectors to address public health risks associated with animal diseases and to combat the spread of antimicrobial resistance in both human and animal health sectors.

Table 13. List of main EU policies enabling the internalization of externalities linked to animal health and welfare in food systems

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Directive 2003/99/EC	On the monitoring of zoonoses and zoonotic agents	Zoonoses - Monitoring	Dec 2003	Apr 2004	Amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC
Regulation (EC) 2160/2003	On the control of salmonella and other specified food-borne zoonotic agents	Zoonoses - Salmonella	Dec 2003	Dec 2003	
Regulation (EC) 1/2005	On the protection of animals during transport and related operations	Transport	Jan 2005	Feb 2005	Amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) 1255/97
Regulation (EC) 1069/2009	Laying down health rules as regards animal by-products and derived products not intended for human consumption	Animal by-products	Dec 2009	Dec 2009	Repealing Regulation (EC) No 1774/2002
Regulation (EC) 1375/2015	Laying down specific rules on official controls for Trichinella in meat	Zoonoses - Trichinella	Aug 2015	Sept 2015	
Regulation (EU) 2016/429	On transmissible animal diseases and repealing certain acts in the area of animal health	Zoonoses - Animal Health Law	Mar 2016	Apr 2021	
Regulation (EU) 2017/625	On official controls and other official activities performed to ensure the application of food and feed	Official Controls	Apr 2017	Dec 2019	Amending Regulations (EC)999/2001, (EC)396/2005, (EC)1069/2009, (EC)1107/2009, (EU)1151/2012, (EU)652/2014, (EU)2016/429 and

	law, rules on animal health and welfare, plant health and plant protection products				(EU)2016/2031 of the European Parliament and of the Council, Council Regulations (EC)1/2005 and (EC)1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC)854/2004 and (EC)882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC
Regulation (EU) 2019/6	On veterinary medicinal products	Veterinary medicinal products	Jan 2019	Jan 2022	Repealing Directive 2001/82/EC
Regulation (EU) 2019/4	On the manufacture, placing on the market and use of medicated feed	Medicated Feed	Jan 2019	Jan 2022	Amending Regulation (EC)183/2005 of the European Parliament and of the Council and repealing Council Directive 90/167/EEC

2.1.2.1 Policies directly related to foodborne zoonoses

The European Food Safety Authorities defines zoonosis as an infection or disease than can be transmitted directly or indirectly between animals and humans, for instance by consuming contaminated foodstuffs or through contact with infected animals (EFSA 2016). According to Wielinga and Schlundt (2013), the majority of zoonotic disease cases are related to animals bred for food purposes, therefore the need to regulate the implementation of adequate agricultural and handling practices.

To that effect, the EU has developed several instruments aimed to protect animal and public health by preventing, controlling, and eradicating the spread of diseases in animals and food products.

2.1.2.1.1 [Directive 2003/99/EC of the European Parliament and of the Council of 17 November 2003 on the monitoring of zoonoses and zoonotic agents](#)

This regulation aims to ensure a coordinated approach to monitoring and controlling zoonotic diseases in the EU by establishing a consistent framework for the collection, analysis, and dissemination of information on the occurrence and distribution of zoonoses and zoonotic agents, as well as the identification of emerging risks across the European Union (Directive 2003/99/EC 2003).

2.1.2.1.2 [Regulation \(EC\) 2160/2003 on the control of salmonella and other specified food-borne zoonotic agents](#)

The regulation aims to control the spread of salmonella and other food-borne zoonotic agents. It requires Member States to establish national control programs for various zoonotic agents in poultry and other animals, as well as to monitor the occurrence of these agents in food products (Regulation (EC) 2160/2003 2003). The regulation also sets out rules for the identification, investigation, and notification of outbreaks of zoonotic diseases.

2.1.2.1.3 [Regulation \(EC\) 1375/2015 laying down specific rules on official controls for Trichinella in meat](#)

This regulation was adopted in 2015 to ensure the safety of meat products in the EU. It aims in particular to ensure that meat from animals infected with *Trichinella* is not placed on the market (Implementing Regulation (EU) 2015/1375 2015). The regulation lays down specific rules for the official controls to be carried out by competent authorities to detect the presence of *Trichinella* in meat. It also sets out rules for the classification and labelling of meat products based on their level of risk for *Trichinella*, as well as the actions to be taken in case of non-compliance with the regulation.

While *Trichinella* monitoring is mandatory at abattoir level in all EU countries, *Salmonella* control plans seem to have been implemented by some countries only, frequently on a voluntary basis (Bonardi et al. 2021). Divergence can be observed between northern and southern EU countries, as the former apply *Salmonella* control programs in pigs for instance, but the latter do not (Bonardi et al. 2021).

2.1.2.1.4 [Regulation \(EU\) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and repealing certain acts in the area of animal health](#)

This regulation, also known as the Animal Health Law (AHL), provides a general framework for the prevention, control, and eradication of transmissible animal diseases. The regulation was adopted in March 2016, and entered into force in April 2021 after a five-year transitional period. The regulation was adopted to establish a single regulatory tool to cover all aspects of animal health, thereby consolidating numerous pieces of

legislation relating to animal health and welfare in the EU, while simplifying and harmonizing the rules across Member States (Loria et al. 2022). It sets out a risk-based approach to animal health, focusing on preventing the entry and spread of diseases, and responding effectively to outbreaks. The Animal Health Law places greater emphasis on biosecurity, early detection, and rapid response to animal disease outbreaks (Loria et al. 2022). It also introduces new measures to improve traceability of animals and animal products and sharing of data on the identification and certification of the animals (Loria et al. 2022). Additionally, the regulation strengthens the role of all relevant actors in the management of animal health.

Related policies:

- Commission Implementing Regulation (EU) 2020/2235 of 16 December 2020 laying down rules for the application of Regulations (EU) 2016/429 and (EU) 2017/625 of the European Parliament and of the Council as regards model animal health certificates, model official certificates and model animal health/official certificates, for the entry into the Union and movements within the Union of consignments of certain categories of animals and goods, official certification regarding such certificates.
- Commission Delegated Regulation (EU) 2020/692 of 30 January 2020 supplementing Regulation (EU) 2016/429 of the European Parliament and of the Council as regards rules for entry into the Union, and the movement and handling after entry of consignments of certain animals, germinal products and products of animal origin.

2.1.2.2 Council Regulation (EC) 1/2005 – Transport

The protection of animals during transport is an important aspect of animal welfare. The European Union has a harmonized legal framework for animal transport, designed to provide a level playing field for operators and a sufficient level of protection for the transported animals (Regulation (EC) 1/2005 2018). Animal transport within the EU is regulated by Regulation (EC) 1/2005 that establishes rules for the protection of animals during transport and related operations within the EU. The regulation came into force in January 2005, and applies to all vertebrate animals transported within the EU for economic reasons, including for slaughter, breeding, production, or any other reason. It sets out specific requirements for the handling and transport of animals, including provisions for the design and construction of vehicles used for transport, the provision of food and water, and the duration of journeys. It also requires that transporters have appropriate training and equipment, and that animals be accompanied by documentation that provides information on their origin, destination, and health status.

2.1.2.3 Regulation (EC) 1069/2009 – Animal by-products

Animal by-products have been legally regulated under EU legislation since 2002. The initial Animal by-products Regulation (EU) No. 1774/2002) provided not only rules for by-product categorization, but also for their collection, transport, storage, processing and use. The Regulation was binding until 3 March 2011, when two new legal regulations entered into force: Regulation (EC). 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and Commission Regulation (EU) No. 142/2011 of 25 February 2011 implementing Regulation (EC). 1069/2009 (Jacek, Marta, and Marek 2011).

Regulation (EC) 1069/2009 aims to prevent and minimize risks to public and animal health arising from animal by-products and derived products, and in particular to protect the safety of the food and feed chain (Regulation (EC) 1069/2009 2009). This regulation establishes, among others, harmonized rules for the production and placing on the market of organic fertilizers and soil improvers.

Related policies:

- Commission Regulation (EU) No 142/2011 of 25 February 2011 implementing Regulation (EC) 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption and implementing Council Directive 97/78/EC as regards certain samples and items exempt from veterinary checks at the border under that Directive

2.1.2.4 Regulation (EU) 2017/625 – Official Controls

Regulation (EU) 2017/625, also known as the EU Official Controls Regulation (OCR), entered into force in April 2017. The regulation establishes rules for official controls, inspections, and other activities carried out by EU Member States along the food production chain to ensure compliance with food and feed law, rules on animal health and welfare, plant health, and plant protection products. The main aim of the regulation is to strengthen the EU's system of official controls and to ensure that they are carried out in an efficient, consistent, transparent and coordinated manner across the entire Union (Regulation 2017/625 n.d.). This includes controls on food and feed businesses, from primary producers to retailers and caterers, but also plant/animal breeders, growers and traders.

Related policies:

- Commission Implementing Regulation (EU) 2020/2235 of 16 December 2020 laying down rules for the application of Regulations (EU) 2016/429 and (EU) 2017/625 of the European Parliament and of the Council as regards model animal health certificates, model official certificates and model animal health/official certificates, for the entry into the Union and movements within the Union of consignments of certain categories of animals and goods, official certification regarding such certificates.

2.1.2.5 Policies related to animal medicines

For the past two decades, concerns regarding antimicrobial use in farm animals grew considerably due to the growing prevalence of antimicrobial resistance (AMR) and the way this affects human health. In the European Union, this political will to contain AMR has led to a European strengthening of the response to AMR with the development of a EU One Health action plan against AMR and the adoption of the animal medicines package including two new regulations on veterinary medicines (Regulation (EU) 2019/6) and medicated feed (Regulation (EU) 2019/4) (EU Monitor 2018; Baudoin, Hogeveen, and Wauters 2021; Simjee and Ippolito 2022). These provide in particular for a wide range of measures to fight antimicrobial resistance and promote a more prudent and responsible use of antibiotics in animals, and are designed to support the Farm to Fork objective of reduction by 50% of the overall EU sales of antibiotics for farmed animals and in aquaculture by 2030 (Simjee and Ippolito 2022).

2.1.2.5.1 Regulation (EU) 2019/6 - Veterinary medicinal products

Regulation 2019/6, commonly known as the New Veterinary Regulation, governs the manufacture, distribution, and use of veterinary medicinal products (VMPs) in the European Union. The regulation entered into force in January 2019 and applies in all EU Member States in January 2022. It repeals Directive 2001/82/EC.

The aim of this legislation is to ensure that VMPs are safe, effective, and of high quality, and that they are used appropriately to protect animal health and welfare, public health, and the environment. In particular, the regulation sets out the requirements for the authorization, registration, and marketing of VMPs, as well as the responsibilities of manufacturers, importers, and distributors. It also includes provisions for the surveillance and monitoring of VMPs once they are on the market, as well as measures to prevent and control the spread of antimicrobial resistance. In addition, the regulation aims to increase transparency and facilitate access to information for stakeholders, including veterinarians, farmers, and the general public.

2.1.2.5.2 Regulation (EU) 2019/4 - Medicated Feed

EU Regulation 2019/4 on medicated feed, on the other hand, sets out rules on the manufacture, placing on the market, and use of medicated feed for food-producing animals in the European Union. It applies in all EU Member States on January 2022 and repeals Council Directive 90/167/EEC. The regulation aims to ensure the safety and effectiveness of medicated feed, to protect public health and animal health and welfare, and to ensure the proper functioning of the internal market.

2.1.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

Tableau 14 provides an overview of the main policy instruments that have been implemented to address a failure in providing an optimal allocation of resources to maximize animal health and welfare in agriculture.

Tableau 14. List of policy instruments used in the main EU policies regulating animal health and welfare in food systems

Instrument category	Instrument topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
					Socio	Envi
C&C Ex-ante risk assessment	Approval processes for animal by-products and medication	Regulations (EC) 1069/2009, (EU) 2019/4	Farmers; Agro-industry;	Consumers	Animal health; Food safety	Toxicity
C&C Market & post-market risk management	Placing on the market and use of animal by-products	Regulation (EC)1069/2009	Farmers; Agro-industry;	Consumers	Food safety	
	Manufacture, storage, transport, placing on the market, prescription and use and disposal of medicated feed	Regulation (EU)2019/4	Farmers; Agro-industry;	Consumers	Animal health; Food safety	Toxicity
	Marketing authorization, supply, use and disposal of veterinary medicinal products	Regulation (EU) 2019/6	Agro-industry;	Consumers	Animal health; Food safety	Toxicity
	Traceability and labelling	Regulations (EC) 1069/2009, (EU) 2019/4, (EU) 2019/6	Farmers; Agri-food industry; Public authorities	Consumers	Consumer rights; Food safety	
	Controls and surveillance	Regulations (EU) 2016/429, (EU) 1375/2015, (EC) 2160/2003, (EC) 1/2005, (EU) 2019/6, (EU) 2017/625, Directive 2003/99/EC	Public authorities Agri-food industry	Consumers	Animal health; Food safety	Toxicity
	C&C Implementing tools	Transport of live animal	Regulation (EC)1/2005	Farmers; Agri-food industry	Animals	Animal health

2.1.4 Evaluation of the impact of the policies instruments on the internalization of externalities

Over time, policies regarding animal health and welfare have developed and transformed in response to the various externalities arising from intensive livestock systems. Environmental and public health pressures aroused from the increase in manure waste, zoonotic diseases, water and soil pollution and greenhouse gas emissions, while additional health issues are associated to antimicrobial resistance (Speeckaert 2022). Increasingly tight regulations on animal health and welfare in the EU have resulted in substantial progress in most productivity factors. Allowing species to live according to their nature and reducing stress is indeed associated to improved processing of fodder, production of milk and eggs, weight gain and reproductive indicators (Vetter, Vasa, and Ózsvári 2014). For instance, the average cow's milk yield is reported to have increased by 20% between 2000 and 2010 across the EU (Vetter, Vasa, and Ózsvári 2014).

However, official studies to support the evaluation of EU animal welfare policies agree that, while progress has been made through increased regulation, the initial objectives still remain highly relevant today (European Commission 2020b; Regulation (EC) 1/2005 2018). Implementation deficits, such as slow or uneven transposition across and within European countries have been noticed for a number of animal welfare regulations (Regulation (EC) 1/2005 2018; Baudoin, Hogeveen, and Wauters 2021; Mateo-Tomás et al. 2022), thereby hindering the potential of these legislations to reduce the externalities of the food systems linked to animal health and welfare.

Finally, it is worth noting that, following a growing involvement of the private sector in the field of farm animal welfare, public policies seem to progressively shift from regulatory to voluntary approaches. This is supported by a study on private and public action for animal welfare in France and Germany by Vogeler (2019), which concluded that private actors are increasingly engaging in farm animal welfare whilst governmental actors are more and more acting with restraint. Retailers in particular are setting their own animal welfare standards by introducing animal welfare labels, thereby obligating farmers to provide animal welfare standards that go beyond legal requirements.

2.1.4.1 *Ex-ante risk assessment*

Assessing risks associated with the use of animal by-products and veterinary medicines before their approval into the EU enables policymakers to ensure compliance with high socioenvironmental standards. During this process, prohibitions and restrictions are identified. For instance, Regulation (EC) 1069/2009 on animal by-products prohibits the feeding of terrestrial animals and farmed fish of a given species with processed animal protein derived from the bodies or parts of bodies of animals of the same species. It goes on to prohibit, for farmed animals, the feeding with catering waste or feed material

containing or derived from catering waste, or the feeding with herbage from land to which organic fertilizers or soil improvers, other than manure, have been applied unless specific conditions (Regulation (EC) 1069/2009 2009). On veterinary medicines, a ban was established in the EU in the late 1990s on growth-promoting antibiotics.

2.1.4.1.1 Social impact

This ex-ante assessment of risks can however lead to measures that are not always fully adapted to the complexity of the system. For instance, the prohibition on growth-promoting antibiotics was then recognized to have had negative social impact in terms of **increased antibiotics resistance**, with associated human health hazard in relation to resistance in salmonellae, campylobacters and zoonotic strains of E. coli. (Casewell et al. 2003). Indeed, the banned growth-promoting antibiotics were actually accompanied by other, previously unrecognized, health promotional or prophylactic effects. Banning these products thus resulted in a deterioration in animal health, including increased diarrhea, weight loss and mortality. Furthermore, it led to the increased usage of therapeutic antibiotics in food animals, which are identical to those used in human medicine. Casewell et al. (2003) therefore argued that policy bans needed to be carefully weighed against the increasingly apparent adverse consequences.

2.1.4.2 Market & post-market risk management

Various regulations are aimed at managing risks related to animal products, by-products and veterinary medicines when introduced onto the EU market or used by agrifood actors. These regulations mandate, on the one hand, the rules to be followed when manufacturing, placing on the market or using such products, and, on the other hand, the control mechanisms to set in place for the management of zoonoses, transport of live animals, and medication. Such controls and surveillances are useful tools to ensure food safety to consumers and to provide evidence for informed decisions on interventions.

2.1.4.2.1 Environmental impact

Some of these regulations are reported to have impacted the environment. For instance, the implementation of Regulation (EC) 1069/2009 laying down health rules as regards animal by-products and derived products not intended for human consumption, and its implementing regulation (EC) 142/2011, have been outlined as a significant achievement for **biodiversity**, and in particular for scavenger conservation in Europe (Margalida et al. 2010; Morales-Reyes et al. 2015; Mateo-Tomás et al. 2022). By allowing farmers to abandon extensive livestock carcasses in the field, these pieces of legislation help guarantee food supply from livestock carcasses to wildlife. Nonetheless, slow or uneven implementation is a major issue with strong potential to compromise the effective achievement of the regulations' objectives, i.e., reconciling biodiversity conservation (through food provisioning for scavengers) and **public health** (by

minimizing the presence of unconsumed carcasses in the field) (Morales-Reyes et al. 2015; Mateo-Tomás et al. 2022). The regulations favoring leaving carcasses in situ for wildlife should also reduce the **GHG emissions** linked to carcass transport and the **costs** associated with that removal, but low compliance prevents that effect (Morales-Reyes et al. 2015).

2.1.4.2.2 Social impact

Regulatory legislations on antimicrobial issues, such as Regulation (EU) 2019/4 on Medicated Feed and Regulation (EU) 2019/6 on Veterinary Medicinal Products, have significantly contributed to **public health** by achieving better antimicrobial use in European livestock production (Simjee and Ippolito 2022; Baudoin, Hogeveen, and Wauters 2021). This is supported by official figures which show a 32,5% decrease in sales of veterinary antimicrobial medicinal products between 2011 and 2017 (Baudoin, Hogeveen, and Wauters 2021).

Animal disease control measures, altogether, are generally considered as effective in controlling and preventing zoonotic diseases (EFSA Panel on Animal Health and Welfare (AHAW) et al. 2021). The introduction of official regulations regarding the obligation to test the meat for specific zoonotic agents is reported to have led to the increasingly rare finding of these zoonotic agents in farmed animals, such as with *Trichinella* in pig production (Bilska-Zajac et al. 2021, 2012–202). This effect is directly associated to improved **public health** thanks to the reduced occurrence of trichinellosis in humans due to the consumption of infected meat.

However, inefficient application of control and surveillance requirements by farmers can lead to continued infection and, thus, to **animal health and welfare** impact, financial **cost** (linked to reduced production quantity and quality, and disease management), as well as social impact due to the **emotional stress** for farmers when dealing with the infections (Crawford et al. 2022). In the study on sheep in Northern Ireland by Crawford et al. (2022), the authors link the inefficiency observed in sheep scab control to knowledge gaps, inadequate resources, poor treatment decisions, under-reporting and low levels of testing. Similarly, inefficient clinical surveillance and risk-based screening of herds is reported by Cárdenas et al. (2019) for early warning in case of bovine brucellosis. While control and surveillance regulation have resulted in large brucellosis-free zones throughout European countries, some countries of Southern Europe remain infected. Possible reasons for the difficulties of bovine brucellosis eradication in this region include, as reported by Cárdenas et al. (2019), the lack of stability of eradication policies, lack of epidemiological data, difficulties of disease eradication in rural areas, lack of laboratory capabilities.

2.1.4.2.3 Economic impact

In addition to the impact on public health, legislation on antimicrobial issues can lead to a reduction in **production costs** on farms (Baudoin, Hogeveen, and Wauters 2021). However, large variations in antimicrobial use trends and in monitoring efforts at farm level have been observed between European countries. This complicates the evaluation of the impact of these regulations on food system externalities at European level.

Nonetheless, stricter regulations of animal health and welfare can be considered globally a burdensome onus for the food industry, imposing important economic **costs** on it (Ferrari 2016; Vetter, Vasa, and Ózsvári 2014; Frisk et al. 2018). The requirements imposed on farmers and operators in the food sector imply the need to reorganize their structures and adopt new precautions, which involve economic costs that do not bring them direct benefits. The study by Fraser et al. (2010) on poultry and pig farmers in the UK shows that their willingness to adopt is inversely related to estimated cost and this is likely to militate against voluntary adoption of measures to control food-borne zoonoses on farms. They go on to mention that if such changes are to be implemented then they are likely to require subsidies or penalties to farmers to facilitate voluntary adoption. Overall, as reported by Vetter, Vasa, and Ózsvári (2014), EU animal welfare policy must be more market-oriented. It is crucial that producers recover their extra costs and that consumers be aware of their responsibility and are willing to pay for food produced in line with the European model.

Regulations on animal welfare is also affecting the **market structure**, as well as **knowledge** and **infrastructure spillovers**. The operators that have failed to comply with the requirements or did not even want to implement them must eventually shut down their activity. Extra costs to comply with the requirements may also cause some operators to go bankrupt. This means a larger market share for competitors that comply with the requirements (Vetter, Vasa, and Ózsvári 2014). Furthermore, the measures and changes taken to fulfil the animal welfare requirements are often accompanied by technological improvements and modernization (Vetter, Vasa, and Ózsvári 2014).

2.1.4.3 Implementing tools

The EU has mandated specific measures to be implemented in order to improve animal health and welfare. For instance, Regulation (EC) 1/2005 on the Protection of Animals During Transport sets out specific requirements for the handling and transport of animals, including provisions for the design and construction of vehicles used for transport, the provision of food and water, and the duration of journeys. However, and as previously highlighted, uneven transposition across MSs results in large discrepancies in the observed outcomes of such regulations. This renders an EU-wide evaluation of these regulations quite challenging.

While slight improvement in **animal welfare** has been observed following the minimizing of pick-up stops and transportation time, big differences remain between Member States as regards the progress made in implementation (Frisk et al. 2018). This has consequences for both **animal welfare** and **competitiveness** of the industry due to uneven playing field for operators (Regulation (EC) 1/2005 2018). Furthermore, it was reported **costs** for transport companies increased after the introduction of the regulation.

2.1.4.4 Synthesis of EU animal health and welfare policies' impacts on social, environmental and economic factors

Table 15 provides a synthesis of the impacts of EU animal health and welfare policies and their instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 15. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU animal health and welfare policy instruments on social, environmental and economic factors

	Social	Environmental	Economic
Ex-ante risk assessment	(+) (-) Antibiotics resistance (/)	(+) (-) (/)	(+) (-) (/)
Market & post-market risk management	(+) Public health (-) Emotional stress (/) Animal health and welfare	(+) Biodiversity (-) (/) GHG emissions	(+) Production costs; (+) Knowledge capital spillovers; (+) Infrastructure spillovers (-) Compliance costs (/) Market structure
Implementing tools	(+) Animal health and welfare (-) Animal health and welfare (/)	(+) (-) (/)	(+) (-) Competitiveness; (-) Compliance costs (/)

3 THE ECONOMIC SPHERE

Support to the agricultural sector

3.1 Income support and incentives to farmers

3.1.1 Introduction

The EU farming system is undergoing various challenges, as for a continuous changing of policy context, the influence of climate change and high volatility of world farming prices (Reidsma et al., 2020). Other profound societal changes such as technological advancements, globalization, and evolving consumer preferences are also modifying the environment in which the EU farming system is developing. Its resilience in delivering private and public goods has been therefore challenged and its stakeholders are facing the consequences, with high levels of heterogeneity amongst regions.

The Common Agricultural Policy (CAP) is the primary regulatory framework for the agricultural activities in the EU. Through various mechanisms such as direct payments, rural development initiatives, and market measures, the CAP seeks to balance the interests of farmers, consumers, and the environment. It aims to strike a delicate equilibrium between fostering agricultural productivity, addressing environmental concerns, and supporting the socio-economic well-being of rural communities. The CAP's evolution over time reflects the EU's commitment to adapting to changing agricultural needs, embracing sustainable practices, and responding to emerging challenges in the farming sector.

The CAP is composed of two principal forms of budgetary expenditure – market support, known as **Pillar One**, and a range of selective payments for rural development measures known as **Pillar Two** (Gay, 2005). Each pillar is regulated by a separate legislative framework, that sets the ground for the budgetary administration, the mandatory requirements and various other guidelines to be implemented at MS level. Across the years, the CAP has experienced a shifting of objectives, and the introduction of new regulations or the amendment of already existing ones, following the development of the societal concerns undergoing those objectives.

If in the early years (1957-1992) the focus was on market interventions and price support to ensure food security and stabilize agricultural markets, but in 1992, the MacSharry Reform marked a turning point. It introduced direct payments to decouple support from production. Such turning point was further enhanced by the 2003 Fischler Reform, aimed at responding to the WTO pressures concerning the coupled subsidies and the unfair competitive advantage of the EU agricultural production (Ciaian, Kancs, and

Paloma 2015). In 2013, the CAP reform introduced the Basic Payment Scheme (BPS), aiming at simplifying direct payments and emphasizing greening.

In parallel, Pillar two emerged in 1999 under the Agenda 2000 reform. The "Health Check" reform in 2005 introduced new measures like agri-environmental schemes and support for organic farming. Finally, the 2013 reform merged various rural development programs, prioritizing strategic programming, innovation, and sustainability.

The evolution of the CAP reflects a broader recognition of the need to balance agricultural productivity with environmental protection, rural development, and social considerations.

3.1.2 Description of the income support and incentives to farmers policies at EU-level

The legislative framework of the Common Agricultural Policy (CAP) encompasses a series of regulations that set out the overarching principles and objectives of the policy. These regulations provide the legal framework for the CAP's implementation and define the general rules and obligations for MS.

For the purpose of the evaluation, we have included the three regulations that are at the basis of the CAP multiannual programming period 2014-2020, even though a more recent one covering the period 2023-2027 is already available. This choice was made to conduct a robust coherent and up-to-date evaluation, as the programming period has been highly mentioned in literature, both academic and mixed one.

Concerning previous regulation periods, the framework 2014-2020 was developed under the Better Regulation (EC, 2021), therefore includes 'lesson from the past' through its evidence-based decision-making, stakeholder consultations and the use of evaluation methodologies to enhance the transparency, accountability, and effectiveness of regulatory measures.

Table 16. List of main EU policies related to the CAP

Policy ID	Title	Topic	Date of entry into force	Date of application	History
Regulation (EU) No 1308/2013	Establishing common organisation of the markets in agricultural products	Single CMO Regulation	December 1, 2013	January 1, 2014	Repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007
Regulation (EU) No 1305/2013	Support for rural development by the European Agricultural Fund for Rural Development (EAFRD)	EU Rural Development	December 17, 2013	January 1, 2014	Repealing Council Regulation (EC) No 1698/2005
Regulation (EU) No 1307/2013	Establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy	Direct payments	December 20, 2013	January 1, 2015	Repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009

3.1.2.1 Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products

Regulation (EU) No 1308/2013, also known as the "Single CMO Regulation," focuses on the common organization of agricultural markets and covers various sectors such as cereals, sugar, milk and dairy products, wine, fruits and vegetables, and olive oil. The regulation establishes a range of measures to support and manage these agricultural markets. It includes market support programs, market intervention mechanisms, market transparency requirements, quality and labelling standards and various types of support to specific sectors. Overall, the regulation aims to strike a balance between the interests

of agricultural producers and consumers while promoting a sustainable and competitive agricultural sector. It seeks to stabilize agricultural markets, provide a safety net for farmers, ensure a fair income for producers, and ensure the availability of quality products for consumers.

3.1.2.2 Regulation (EU) No 1305/2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD)

Regulation (EU) No 1305/2013 is a key legislation that governs the support for rural development provided through the European Agricultural Fund for Rural Development (EAFRD). The regulation outlines the objectives, principles, and measures for promoting rural development across the European Union.

The regulation aims to promote sustainable development, enhance the competitiveness of rural areas, and support the implementation of the Common Agricultural Policy (CAP). The regulation encompasses a wide range of measures.

Firstly, there are support schemes for investments in agricultural holdings, which aim to modernize and improve the competitiveness of farms. These schemes cover areas such as farm infrastructure, machinery, and equipment, as well as the diversification of agricultural activities.

Secondly, the regulation includes measures to support Agri-environment-climate initiatives, aiming to preserve and enhance the natural environment. These initiatives promote and incentivize environmentally friendly farming practices, biodiversity conservation, organic farming, and the sustainable management of natural resources.

Furthermore, the regulation supports forestry-related measures, including afforestation, forest management, and investments in forestry technologies.

The regulation also includes measures to encourage cooperation among farmers, facilitating the establishment of producer groups and operational groups. These groups promote collaboration, knowledge exchange, and innovation in agricultural and rural development.

The regulation provides the support for rural business development and diversification, financing initiatives aiming at stimulating economic growth, creating employment opportunities, and enhancing the quality of life in rural areas.

The regulation encourages Member States to develop comprehensive rural development strategies aligned with EU objectives and tailored to the specific needs and potentials of their regions.

3.1.2.3 Regulation (EU) No 1307/2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy

The policy instruments under Regulation (EU) No 1307/2013 govern direct payments to farmers within the Common Agricultural Policy (CAP) framework. The general aim is to

provide income support to farmers, encourage sustainable agricultural practices, and promote the efficient use of resources.

The main instrument is the Basic Payment Scheme (BPS), which calculates payments based on eligible hectares, historical references, and regional rules. This scheme is complemented by redistributive payments, targeting smaller and medium-sized farms to ensure fairer distribution of support. The regulation also includes provisions for young farmers, offering additional support to facilitate their entry into the agricultural sector. The regulation relies on cross-compliance requirements, which ensure that farmers adhere to environmental, public health, animal welfare, and food safety standards. Non-compliance with these requirements may result in the reduction or withdrawal of direct payments. Additionally, the regulation promotes the implementation of agri-environmental and climate measures, encouraging farmers to adopt sustainable farming practices and contribute to environmental protection. To ensure proper administration and control, the regulation establishes a system for integrated administration, including the use of satellite imagery and on-the-spot checks. This allows for accurate verification of eligibility and compliance.

3.1.3 Main policy instruments and mechanisms for the internalization of externalities at EU-level

While the legislative framework provides the overall structure and guidance for the CAP, the policy instruments are the practical tools used to implement and operationalize the policy goals on the ground. These instruments can vary across different legislative frameworks within the CAP, as they are designed to address specific challenges and priorities.

However, there are also policy instruments that are common to different legislative frameworks as they are financed under various regulations governing the CAP. We have identified three main type of policy instrument i) **the income support and subsidies schemes**, ii) **the voluntary schemes and financial incentives** and iii) **market support schemes**. If the first category of policy instruments is designed to provide income support and stabilize agricultural market, the second focuses on rural development and includes a range of financial incentives and support measures, varying from sustainable farming practices, environmental stewardship, and diversification of rural economies. The third aims at stabilizing market, balancing dynamics across the value chain and overall guarantee a balanced level of agricultural productivity.

Table 17. List of policy instruments used in the CAP

Instrument	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
				Eco	Envi
Income support & subsidies	Regulation (EU) 1307/2013	Farmers	Farmers & Society at large	Farmers living standards	Climate change Biodiversity loss Soil destruction
Voluntary schemes & financial incentives	Regulation (EU) 1305/2013	Farmers	Society at large	Rural development challenges	Climate change Biodiversity loss Soil destruction
Market support schemes	Regulation (EU) 1308/2013	Farmers & Agro-industry	Society at large	Market stability and price volatility	

3.1.3.1 Income support & subsidies

Income support to farmers started, in the form we know them now, under the Mac Sharry reforms. These reforms brought about a partial shift from market price support linked to specific quantity of production based on specific quantities (e.g. tones, liters) to direct payments per hectare or animal, introducing what is known as coupled payments (Dries et al., 2019). Such shift was further developed under the reform in 2003, in response to pressure from the World Trade Organization (WTO) concerning unfair advantages provided to the EU's agricultural sector (i.e. price support role in maintaining EU agricultural commodity prices above global prices). This reform progressively decoupled payments from production and introduced decoupled payments, which have become the largest component of the CAP budget (Ciaian, Kancs, and Paloma 2015).

Under the CAP programming period 2014-2020, there are therefore two main types of income support: i) Basic Payment Schemes and ii) Decouple Direct Payments. The first one provides direct income support to farmers based on the eligible hectares of agricultural land they own or manage. The payment amount is determined by factors such as historical reference amounts, entitlements, and land use. The second one allows Member States to provide additional targeted support to specific sectors or regions facing specific challenges. It can be coupled to specific agricultural activities, such as livestock production or certain crops.

The CAP provides another series of **subsidy schemes**, targeting specific actors of the farming systems or aiming for some transition towards a more sustainable EU farming system. Such schemes are defined and supported according to the priorities defined under the programming period. For the CAP programming period 2014-2020, the following schemes were provided to MS to implement at their territorial level (First Pillar of the Common Agricultural Policy (CAP), 2022):

Support to target actors:

- Young farmers scheme (mandatory for Member States): in order to promote the entrance of young farmers into the agricultural sector and ensure generational renewal, a specific provision is in place to support them. Young farmers, defined as newcomers under the age of 40 who have established their farming operations within the past five years, receive an additional 25% increase in the basic payment for the initial five years. This supplement is financed through a 2% allocation from the national budget, and all Member States are obligated to implement this measure.
- Small farmers scheme (voluntary for Member States): this scheme allows for an annual payment of up to EUR 1,250 to be made to small farmers, regardless of their farm size. Participants in this scheme benefit from reduced cross-compliance requirements and are exempt from meeting the greening requirements (see next section for the above-mentioned measures). The implementation of the small farmers' scheme is subject to a maximum cost of 10% of the national funding allocation, unless Member States choose to guarantee that small farmers receive the same level of payment they would have received without the scheme.

Pursuing environmental objectives:

- Greening: (mandatory for Member States, mandatory for farmers): farms will be eligible to receive an extra payment per hectare for adopting climate and environment-friendly farming practices. Member States are required to allocate 30% of their national funding towards this greening payment. The greening measures encompass three main aspects: i) crop diversification, ii) preservation of existing permanent grassland, and iii) maintenance of an 'ecological focus area'. To avoid placing undue burden on farmers who are already implementing environmental and sustainability practices, the regulation introduces a 'greening equivalency' system. This system acknowledges that farmers who have already adopted environmentally beneficial practices are considered to have met the basic greening requirements.
- Cross-compliance (mandatory for Member States, mandatory for farmers): the provision of cross-compliance requirements was simplified, linking direct

payments to farmers' compliance with Member State standards on environmental and agronomic conditions, including soil conservation and maintenance. Additionally, adherence to EU regulations on public health, animal health, environment, and animal welfare is required. Failure to meet cross-compliance rules may result in the reduction or cessation of direct payments.

3.1.3.2 *Voluntary schemes & financial incentives*

The CAP programming period 2014-2020 has also developed a series of tools to target actions towards a more sustainable EU agri-food system, aiming for environmental and social goals. On this, the second pillar focuses on rural development and includes various voluntary schemes and financial incentives aimed at achieving some specific objectives. These objectives encompass a broad range of areas, including environmental sustainability, climate change mitigation and adaptation, support for agri-food quality schemes, farm modernization and restructuring, and fostering the diversification of rural economies.

The *Agricultural Environmental and Climate Measures* (AECM) represent the biggest **voluntary scheme** under the second pillar of the CAP. The primary purpose of the AECM is to incentivize farmers to adopt practices that enhance environmental protection, biodiversity, and climate resilience. There are various types of AECM available to farmers, including agri-environmental schemes, climate-smart farming practices, and investments in renewable energy and energy efficiency. Participation in AECM is voluntary, and requires a commitment under a multi-year program, often spanning five years. Participating in AECM requires farmers to adhere to certain obligations and requirements as outlined by their respective Member State. These can include adopting specific farming practices, such as crop diversification, wildlife habitat creation, or soil conservation techniques. Farmers may need to allocate specific areas of their land for environmental purposes or follow guidelines related to pesticide and fertilizer use. Compliance with these obligations is essential to continue receiving the financial support and incentives associated with AECM.

The CAP provides other **financial incentives**, targeting rural development issues such as supporting agri-food quality production at local and regional level, and investing in farm modernization and restructuring. Through the support for *Agri-Food Quality Schemes* it promotes and protect high-quality agricultural products with specific characteristics linked to geographical origin (Geographical Indications), traditional production methods (Traditional Specialties Guaranteed), or organic farming practices (Organic Farming). It aims to enhance the value and market recognition of these products, while ensuring consumer trust and supporting rural economies. The support includes financial assistance for obtaining quality certifications, implementing quality control measures, carrying out promotional activities, and improving product marketing. Through this

instrument, farmers and producer groups are encouraged to adopt sustainable production methods, preserve traditional know-how, and maintain the authenticity and unique qualities of their agricultural products.

EU farmers have access to *Farm Modernization and Restructuring Incentives*, aiming at supporting farmers in modernizing their agricultural practices and restructuring their farms to improve competitiveness, productivity, and sustainability. These incentives provide financial assistance for investments in new technologies, equipment, infrastructure, and farm restructuring projects. Examples of eligible activities include the adoption of precision farming techniques, investment in renewable energy systems, construction of modernized farm buildings, and the diversification of farm activities. Financial support is typically provided as grants or subsidized loans, and the eligibility criteria and application process vary between Member States.

3.1.3.3 Market support schemes

Along with direct income support and rural development voluntary schemes, market support schemes have been a key component of the CAP programming period 2014-2020, aiming mainly at stabilizing markets, but also ensuring a fair standard of living for farmers, and increase agricultural productivity. These schemes fall mainly under the Common organization of the markets (CMO) Regulation (EU) No 1308/2013. They are applied to a restricted list of products and, after the reform of 2003, the intervention tools under this type of policy instrument were changed considerably, and they are now regarded as 'safety nets', i.e. they are used only in the event of crises linked to serious market disruption.

The funding available should account for approximately 4 % (EUR 17.5 billion) of the total CAP budget, and is managed by the European Agricultural Guarantee Fund (EAGF). In 2019, market intervention measures were around EUR 3.4 billion, i.e. 5.5 % of total EAGF expenditure. They can be grouped in four main categories and Table 18 shows the funding share for the period 2014-2019.

Table 18. EAGF expenditure on agricultural market intervention (EUR million – current prices)

	2014	2015	2016	2017	2018	2019
Storage	5.1	18.4	52.4	27.6	182.3	3.0
Export refunds	4.5	0.3	0.6	0.0	0.2	1.1
Other market measures	2 579.6	2 698.0	3 185.2	3 061.1	2 544.6	2 427.8
Total	2 589.2	2 716.7	3 238.2	3 088.7	2 727.1	3 431.9

3.1.4 Evaluation of the impact of the policies instruments on the internalization of externalities

3.1.4.1 Income support and subsidies

As for its implication in both internal and external market dynamics, subsidies and income support schemes provided through CAP framework have a significant impact within the EU. Their main contributions relate to the economic sphere, as they play (and have played) a pivotal role in the production volumes, trade, and market dynamics, influencing the overall economic performance and outcomes of the agri-food sector. Even though the general aim of those policy instruments is to support and protect EU farmers and ensure a stable food supply, the allocation and distribution of subsidies can have unintended consequences, leading to both positive and negative economic externalities. These externalities encompass various aspects, including on the one hand market distortions, income disparities, competitiveness, resource allocation, and on the other incentives to rural jobs interindustry spillovers, effect on non-farm employment, environmental impacts, etc (Ciaian, Kancs, and Paloma 2015; Rizov, Davidova, and Bailey 2018; Schuh et al. 2016).

3.1.4.1.1 Economic impact

Subsidies and income support schemes have a significant impact on economic externalities, crosscutting several dimensions of the agri-food system. In line with their main goal, they have a direct impact on farmers' incomes, providing them with stability and support in an often-unpredictable market environment. As a consequence, they could play a pivotal role in **employment**, securing rural jobs, and contributing to the vitality of rural communities. But the effect could highly vary across regions and MS, and in some cases even generate additional negative economic externalities. A comprehensive report of 2016 commissioned by the European Parliament's Committee on Agriculture and Rural Development (COMAGRI) analyzed 53 studies to assess the impact of the Common Agricultural Policy (CAP) on rural job creation (Schuh et al., 2016).

The findings revealed varying perspectives on the direct effect of the CAP generally on employment in agriculture. Out of the studies reviewed, 16 reported a negative effect, indicating a potential decline in agricultural jobs. Conversely, nine studies indicated a positive effect, suggesting a potential increase in employment opportunities in the agricultural sector. Eight studies highlighted mixed effects, with outcomes dependent on farm structure and the broader rural economy, while six studies found no significant effect.

Additionally, the support offered by CAP subsidies can have indirect effects on off-farm employments of farmers, as could provide assets allowing them to invest in new technologies, and enhance their competitiveness, ultimately stimulating employment opportunities in related sectors. Also, in this case a high degree of heterogeneity characterizes the EU context.

From a **value chain** point of view, the infusion of direct payments into the agricultural sector could mean benefit (or loss) on both input and output markets. Firstly, they have the potential to raise input prices, such as those for fertilizers, land, and capital, which can benefit input suppliers in the agricultural sector. Secondly, subsidies may result in lower output prices, providing consumers with policy gains through more affordable agricultural products (Goodwin & Ortalo-Magné, 1992; Kilian et al., 2012; Weersink et al., 1999). The reason behind is that subsidies and income support schemes under pillar I are linked to a specific input use (for example, land) or output produced, and thus stimulate farms' demand on input markets and higher supply of production on output markets. Both effects have a detrimental impact on farm income, as stronger input demand increases input prices, while higher availability of supply on the output market reduces their prices (Ciaian, Kancs, and Paloma 2015).

Lastly, the effect of CAP direct payments on **consumers** can be observed through changes in output demand elasticities. By providing income support to farmers and ensuring a stable food supply, CAP subsidies can help moderate price fluctuations and maintain affordable food prices for consumers.

3.1.4.1.2 Environmental impact

programming period aimed to address environmental externalities associated with agricultural practices. An assessment provided included in the volume 'The Economics of regulation in Agriculture: compliance with public and private standards' (Hart et al., 2012) underlines the positive effects cross-compliance by promoting sustainable farming practices and addressing environmental challenges such as soil erosion, biodiversity loss, and water pollution. By imposing statutory management requirements, cross compliance encourages farmers to adopt environmentally friendly practices. However, there are also negative effects to consider. But the authors also underline that cross-compliance standards can be burdensome and may not always lead

to significant environmental improvements. Additionally, the rigid nature of cross compliance may not adequately address region-specific environmental issues. Nevertheless, efforts are ongoing to enhance its effectiveness in achieving positive environmental outcomes within the CAP framework. The authors also underline some substantial limitations in assessing the impacts of such measures, including the lack of comprehensive data on the implementation and enforcement of cross-compliance requirements, as well as the difficulty in attributing specific environmental outcomes solely to cross-compliance. These challenges hinder the accurate assessment of the effectiveness and environmental impacts of cross-compliance in achieving the desired policy objectives.

The new CAP programming period 2023-2027 has introduced a new measure, the eco-schemes. They have a broader objective of promoting agricultural practices that contribute to environmental and climate goals. Unlike the greening measures, the participation in eco-schemes is voluntary for farmers. They provide financial incentives to farmers who voluntarily adopt specific agri-environmental practices that go beyond the basic requirements of greening. The eco-schemes offer more flexibility and customization options compared to the standardized greening measures, trespassing some of the limits identified for the previous programming period and previous measures. As for their recent implementation, an assessment of their environmental performance in internalizing environmental externalities is not yet available in both academic and grey literature, yet some studies assess the challenges and trade-offs with which national policy designers have to contend in devising national eco-schemes for agriculture (Birkenstock & Röder, 2019; Latacz-Lohmann et al., 2022).

3.1.4.2 Voluntary schemes and financial incentives

3.1.4.2.1 Environmental impact

The Agricultural Environmental and Climate Measures (AECM), along being the main policy instrument under the second pillar, have been charged with most of the environmental objectives of the CAP. These measures are designed to mitigate and reduce the negative effects of agriculture on the environment, promote sustainable land management, and protect natural resources. By implementing various practices and techniques, such as soil conservation, water management, biodiversity preservation, and agri-environmental infrastructure development, the AEM seeks to promote a more environmentally friendly. Yet, (Farmer et al., 2008) emphasized the urgent need for approaches that specifically address the spatial correlation between the uptake of AECM and environmental indicators at large spatial scales, to elucidate the impact of agri-environmental payments on ecological targets (Früh-Müller et al., 2019). During the last decades, various researchers have raised an interest in the extent to which AECM enhance environmental quality and ecosystem functioning has increased strongly in recent years (Giovanopoulou et al., 2011; Kleijn & Sutherland, 2003; Scheper et al., 2013;

Whittingham, 2011). Those same authors (Kleijn & Sutherland, 2003; Schmidtner et al., 2012; Zimmermann & Britz, 2016) have, in some cases, underlined a negative correlation between AECM payment and environmental impact indicators. Another recurrent criticism relates to the lack of rigor in the conditions under which the payments are made within the AECM schemes (Kleijn et al., 2004; Pe'er et al., 2014; Prager & Nagel, 2008).

However, assessments of the ecological consequences of specific AECM are generally confined to selected regions (Raggi et al., 2015; Uthes & Matzdorf, 2013).

This regional focus in the evaluation process may hinder a comprehensive understanding of the broader impacts of AECM across different agricultural contexts within the European Union (EU). Such a comprehensive assessment is, to our knowledge, far from being compiled. This also relates to the lack of robust and coherent evaluation framework. The CAP regulatory framework relies on CAP Common Monitoring & Evaluation Framework (CMEF) to assess its environmental objectives, and the effectiveness of the implementation of its policy instruments (e.g. AECM) to achieve them. However, the impact indicators of the CMEF primarily focus on measuring changes in specific components of natural capital, such as soil carbon content, nitrates concentration in groundwater, and farmland biodiversity. Unfortunately, these indicators do not directly capture the broader effects of these changes on ecosystems and the services they provide, such as the soil's contribution to biomass production or crop pollination (Pe'er et al., 2014). To address this limitation, Member States have the option to complement CMEF indicators with national indicators; however, this approach is often hindered by insufficient data availability. Consequently, many evaluations rely on proxy indicators, such as land use patterns and farming practices, as indicators of environmental effects (Dupraz & Guyomard, 2019; Primdahl et al., 2003). These proxy indicators are assumed to reflect a cause-effect relationship with the environmental objectives of AECM. However, research by suggests that such assumptions are often not supported by scientific evidence.

3.1.4.2.2 Economic impact

In areas where the implementation of AECM has generated positive environmental impacts (such as enhanced soil fertility, reduced pollution, and better water management), some second positive loop could also take place, as increased agricultural productivity, lower production costs, and improved farm profitability in the long run. Through the preservation of biodiversity and the provision of ecosystem services, some positive impact could be generated on tourism, recreational activities, and the overall quality of life in rural areas.

However, AECM may require changes in farming practices or the adoption of costly technologies, which can initially increase production costs for farmers. Additionally,

AECM may impose compliance and administrative burdens on farmers, leading to additional costs in terms of time, paperwork, and potential penalties for non-compliance (Matzdorf and Lorenz 2010). These costs can be particularly challenging for small-scale and less financially resilient farms. Moreover, the implementation of AECM may lead to reduced agricultural production in some cases, potentially affecting the availability and affordability of certain agricultural products for consumers.

As scientific evidence on the effect of AECM and other voluntary schemes under the second pillar of the CAP is lacking, the information provided in the paragraph comes from internal knowledge (i.e. stakeholders' engagements, previous projects, partners).

3.1.4.3 Market support schemes

3.1.4.3.1 Economic impact

Market support schemes implemented under the Single Common Market Organization (CMO) Regulation (EU) 1308/2013 aim to strike a balance between market stability, income support for farmers, and fairer trading practices. However, it remains a complex and evolving framework with both positive and negative implications for the agricultural sector in the European Union. If on one hand they aimed at promoting market stability and the reduction of price volatility through the implementation of market management measures (e.g. public intervention, private storage aid, and withdrawal schemes), it is also true that they could lead to distortions in the market. Payments and subsidies under the CMO can create market inefficiencies, potentially leading to overproduction and excess supply. This can result in downward pressure on prices, affecting the competitiveness of certain agricultural sectors. Furthermore, unbalances across stakeholders of the value chain could occur, as for example farmers receiving a smaller share of the final consumer price, impacting their income and potentially leading to financial challenges for certain agricultural enterprises.

As scientific evidence on the effect of market support schemes of the CAP is lacking, the information provided in the paragraph comes from internal knowledge (i.e., stakeholders' engagements, previous projects, partners).

3.1.4.4 Synthesis of EU CAP's impacts on social, environmental and economic factors

Table 19 provides a synthesis of the impacts of EU CAP and its instruments on social, environmental and economic externalities, as suggested by the literature review.

Table 19. Synthesis of reviewed positive (+), negative (-), and non-directional (/) impacts of EU CAP instruments on social, environmental and economic factors

	Social	Environmental	Economic
Income support & subsidies	(+) (-) (/)	(+) Promote sustainable farming practices (-) (/) Soil erosion (/) Biodiversity loss (/) Water pollution	(+) Farmers' income (+) Consumers' prices (decrease) (+) Rural jobs (-) Input prices (increase) (-) Rural jobs (/)
Voluntary schemes & financial incentives	(+) (-) (/)	(+) Promote sustainable farming practices (-) Promote sustainable farming practices (/)	(+) Production costs (decrease) (-) Penalties (-) Administrative burdens (-) Production costs (increase) (/)
Market support schemes	(+) (-) (/)	(+) (-) Overproduction (/)	(+) Reduced price volatility (-) Unbalance in value-added redistribution (-) Overproduction (/)

4 Conclusion

Observations about the EU system:

The EU evaluation frameworks: An integral part of the EU policy cycle, defined also under the Better Regulation, is the phase of the policy evaluation, that should assess the effectiveness, efficiency, and impact of policies. Yet, it has been reported, under various policy frameworks analyzed within the report, that this phase often presents severe flaws. Just to mention: lack of robust indicators, problem in data collection, inadequate stakeholders' engagement.

Precautionary principle: Throughout its legislative history, the EU has adopted a robust precautionary approach to manage societal issues. In particular, in the wake of the mad cow food safety crises that hit the EU in the 1990s, the Union embarked on significant regulatory efforts to effectively address the issue and ensure robust precautionary measures for the future. It should be noted that at Member States' level, divergences in the sociocultural, political and environmental contexts might result in different application and interpretation of the precautionary principle.

Subsidiarity: The subsidiarity principle, designed to decentralize decision-making for efficiency and local relevance, introduces a dual challenge. While it fosters more relevant policies at local scale, it also leads to fragmented and inconsistent implementation, contributing to varying impacts across Member States. Overall, this heterogeneity can result in varying economic, environmental and social impacts of EU regulations.

Territorial heterogeneity: Despite the harmonization efforts pursued in the last decades, the legislative context of the EU remains largely affected by strong territorial heterogeneities across Member States. This is partly due to the principle of subsidiarity, which leaves MSs to adopt the rules most relevant at decentralized level. This is also linked to the various degree of compliance with regulations.

Impact of European regulations on externalities:

- Overall, current legislation at EU-level consists essentially of **command-and-control** (regulatory) instruments, as opposed to market-based instruments. This might be due to the difficulty of establishing fair and effective market instruments such as taxing schemes at the level of the whole Union. These command-and-control regulations establish constraints on inputs or outputs to bring food production systems in line with more optimal levels, rather than directly targeting costs and/or prices in the systems.

- The state of the EU nowadays suggests **little effect** of past regulations in improving global sustainability. Trends in the use and risks associated with pesticides and fertilizers and the state of fisheries, for instance, have not displayed satisfactory improvements in the last decades. The review suggests that the policy instruments under scrutiny in the present report have, at minimum, zero impact – or balancing positive effects in some territories and negative effects in others – and, in some worse cases, lead to negative impacts (ex. the Landing Obligation in the fisheries sector leading to illegal discards, thereby continuing fish stock depletion and causing false reporting and thus erroneous data for assessment). However, the lack of counterfactual situation precludes any comparison with the state the EU would be in today in the absence of these regulations.
- The low effectiveness of EU regulations in achieving sustainability objectives might be related to frequent issues of **implementation and compliance** within Member States. Stronger EU legislative efforts should be allocated to address that shortcoming.
The strong heterogeneity across MSs’ sociocultural, political and environmental contexts might be the source of divergences in the levels of compliance with uniform EU regulations. Differences in production or compliance costs, for instance, will create different incentives for each MSs to adopt a regulation.
- The low effectiveness of EU regulations in achieving sustainability objectives could also be linked to the targeted objectives themselves. The **economic interests** of major players in the systems seem to remain at the core of most EU regulations. This was observed in the thematic of fisheries, as well as for pesticide, fertilizers and animal welfare, which are associated with intensive farming systems. In these sectors, sustainability criteria are pushed behind and regulations fail to consider the integrated aspects of human health, animal health, and the environment.
As noted by Libecap (2009), the party involved in decision-making – actual users of a resource, regulators, politicians – are generally not a residual claimant to the social gains from more optimal resource management and use. Accordingly, decisions tend to align with private returns rather than capture socioenvironmental returns for society as a whole.
- It should however be noted that the EU policy framework addresses very **complex issues**, such as food safety, transparent information sharing along value chains, and halting and reversing biodiversity losses. Reducing negative impacts and fostering positive behaviors in food systems to address these issues is

therefore by definition an extremely difficult task. The heterogeneity of contexts encountered at MSs level further complicates the task.

- A common characteristic of all regulations is that they entail **implementation costs**. These costs, referred to as transaction costs, cover all direct and indirect costs that are to be made when it is decided to restrict or regulate an activity, including costs of implementation and of compliance.
An issue frequently associated with command-and-control regulations is that they generate high compliance costs for the private sector. This is often mentioned as a cause for the lack of efficiency of such regulations. As a general observation, policies should always keep in mind that the costs of regulation ought to be lower than the welfare gains of internalizing the externalities. This however suggests that decision-makers should have information not only about socio-environmental costs and optimal levels to be attained, but also about the private production and compliance costs of users. This is a significant challenge for the implementation of effective policies.
- European legislation places a strong emphasis on the traceability of food products and on the provision of adequate and transparent information to consumers. Accordingly, food products are subject to strict **labelling** obligations. In addition to protecting consumers, these labelling requirements also protect the EU market by ensuring that products entering the EU meet certain socioenvironmental standards.

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Annexes

Annex 1. Overview of the instruments cited in this report and related policies

Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
Command and Control	Ex-ante risk assessment	Fertilizers	Conformity	Regulation (EU) 2019/1009	Industry	Society at large	Food safety; Animal Welfare	Climate change; Acidification & eutrophication; Direct effects on biodiversity & ecosystems; Toxicity
		Pesticides	Approval of active substance	Regulation (EC) 1107/2009	Industries	Society at large	Food safety	Undissociated
		Pesticides	Approval of PPP	Regulation (EC) 1107/2009	Public authorities	Society at large	Food safety	Undissociated
		Pesticides	MRL establishment	Regulation (EC) 396/2005	Industries	Consumers	Food safety	
		GMO	GM crops, food and feed risk assessment	Directive 2001/18/EC; Regulation (EC) 1829/2003	Public authorities	Society at large	Human health; Animal health	Undissociated
		Animal health & welfare	Approval processes for animal by-products and medication	Regulations (EC)1069/2009, (EU) 2019/4	Farmers; Industries	Consumers	Animal health; Food safety	Toxicity
	Market & post-market risk management	Fertilizers	Labelling	Regulation (EU) 2019/1009	Industry	Farmers	Consumers' rights	
		Pesticides		Regulation (EC)1107/2009	Industries	Farmers	User's right	



Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
		Fisheries		Regulation (EU)1380/2013; Regulation (EU) 1379/2013	Fishing industry	Fisheries	Health; Consumer right	Undissociated
		GMO	Traceability and labelling	Regulation (EC)1829/2003; Regulation (EC)1830/2003; Regulation (EC)1946/2003	Industries; Farmer	Consumer	Consumer right	
		Animal health & welfare		Regulations (EC)1069/2009, (EU)2019/4, (EU)2019/6	Farmers; Industries; Public authorities	Consumers	Consumer rights; Food safety	
		Pesticides	MRL controls	Regulation (EC)396/2005	Public authorities	Consumers	Food safety	
		GMO	Monitoring & Surveillance	Directive 2001/18/EC; Regulation (EC) 1829/2003	Industries; Farmers	Society at large	Human health; Animal health	Undissociated
		Fisheries	Catch certification scheme (imports)	Regulation (EU)1380/2013; Regulation (EC) 1005/2008	Fishing industry	Fisheries	Transparency	Undissociated
		Fisheries	Controls (EU activities)	Regulation (EC) 1224/2009	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
		Animal health & welfare	Placing on the market and use of	Regulation (EC)1069/2009	Farmers; Industries	Consumers	Food safety	



Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
			animal by-products					
		Animal health & welfare	Manufacture, storage, transport, placing on the market, prescription and use and disposal of medicated feed	Regulation (EU)2019/4	Farmers; Industries	Consumers	Animal health; Food safety	Toxicity
		Animal health & welfare	Marketing authorization, supply, use and disposal of veterinary medicinal products	Regulation (EU) 2019/6	Industries	Consumers	Animal health; Food safety	Toxicity
		Animal health & welfare	Controls and surveillance	Regulations (EU) 2016/429, (EU)1375/2015, (EC)2160/2003, (EC) 1/2005, (EU) 2019/6, (EU) 2017/625, Directive 2003/99/EC	Public authorities Industries	Consumers	Animal health; Food safety	Toxicity



Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
	Implementing tools	Fertilizers	Agricultural Practices & Action Programmes	Directive 91/676/EEC	Farmers	Society at large	Food safety; Animal Welfare	Climate change; Acidification & eutrophication; Direct effects on biodiversity & ecosystems; Toxicity
		Pesticides	National Action Plan	Directive 2009/128/EC	Public authorities & Farmers	Society at large	Food safety	Undissociated
		Fisheries	Landing obligations	Regulation (EU) 1380/2013	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
		Fisheries	Technical measures (Minimum fish sizes, fishing gear, etc.)	Regulation (EU) 380/2013; Regulation (EU) 2019/1241	Fishing industry	Fisheries		Effects on biodiversity & ecosystems
			Transport of live animal	Regulation (EC)1/2005	Farmers; Industries	Animals	Animal health	
Market support		Fisheries	Quotas	Regulation (EU) 1380/2013	Fishing industry	Fisheries		Effect on biodiversity & ecosystem
		Fisheries	Fisheries subsidies	Regulation (EU)1380/2013; Regulation (EU) 508/2014 ; Regulation (EU) 2021/1139	Fishing industry	Fisheries	Undissociated	Undissociated
		CAP	Income support & subsidies	Regulation (EU) 1307/2013	Farmers	Farmers & Society at large	Farmers living standards	Climate change; Biodiversity loss; Soil destruction



Instrument category		Thematic	Instrument Topic	Regulation	Primary target	Ultimate beneficiary	Targeted externalities	
							Socio	Envi
		CAP	Voluntary schemes & financial incentives	Regulation (EU) 1305/2013	Farmers	Society at large	Rural development challenges	Climate change; Biodiversity loss; Soil destruction
		CAP	Market support schemes	Regulation (EU) 1308/2013	Farmers & Agro-industry	Society at large	Market stability and price volatility	

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