



# **Working title: Water and agriculture**

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## **Foreword/Preface (Only in exceptional cases and in agreement with COM)**

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## Acknowledgements

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## Key messages

- The Water Framework Directive has the objective to achieve good status of water by 2015. As good status is also associated with near natural ecological conditions, this objective is also interpreted as achieving sustainability for water.
- Currently a large share of surface and groundwater bodies in EU-27, United Kingdom, and Norway are not achieving good status as required by the Water Framework Directive, in part due to pressures from agricultural activities. Although point source pollution, nitrogen surplus and water abstraction have been reduced, diffuse pollution of nutrients and chemicals from agriculture remain a significant pressure to one third of surface and groundwater bodies in Europe, and are a main pressure to Europe's seas. Water abstraction for irrigation accounts for up to 80% of water abstracted in parts of Europe, and water storage, drainage and land reclamation projects are linked to considerable hydromorphological pressures. Climate change exacerbates those pressures due to increasing temperatures, and altered and less predictable precipitation patterns. In combination these pressures are both of risk to the environment, but also to the agricultural production itself, if resources become critically scarce.
- Due to the close link between pressures and agricultural activities, achieving sustainability for water and Water Framework Directive objectives needs to build on expanding the uptake of sustainable agricultural practices. Such practices also enhance the resilience of the agricultural production to climate pressures, and would also benefit biodiversity, but may reduce agricultural yields.
- Consumer, industry, and policy demands within food and energy systems has a large influence on the agricultural production and specific choices of farmers, hence on our ability to reach environmental targets. Managing sustainably in this context requires balancing the need for affordable products, social wellbeing and fairness, and environmental protection while acknowledging trade-offs.
- A wide variety of management measures exists within the EU policy framework to tackle agricultural pressures on the water environment. To date, most measures implemented have sought to improve water management and increase the efficiency of resource use in agriculture. This has resulted in significant improvements, but more ambitious uptake of sustainable agricultural production to reduce total resource use is needed. To achieve this transition, ambitious policies are needed as fundamental changes in the agricultural sector will be required.
- Greater coherence is needed between EU environmental policies and the sectoral EU policies supporting agricultural production. Recent decades have seen improved integration of water targets in the Common Agricultural Policies. However, future agricultural policies need to be more ambitious on the scale of change needed in production systems. More systematic attention is needed to the ways CAP regulatory and incentive instruments support transition in farming production coherent with environmental goals, especially because the CAP is the most important fund for achieving WFD objectives.
- With its ambitious policy initiatives, including the proposed EU Climate Law, Adaptation Strategy, Biodiversity Strategy, the Farm to Fork strategy, and the Zero Pollution Action Plan, the European Green Deal has articulated the ambition to move Europe on to a more sustainable development path, and will need to consider the relationship between the agricultural sector and its environmental impacts.



## Executive summary

Recently the European Union has adopted the Green Deal, which through its EU Climate Law, its Biodiversity 2030 Strategy, Farm to Fork Strategy, and Zero Pollution Action plan, aims to put Europe on a path of sustainable development. Among the many aspects of achieving this objective, Europe will need to consider the relationship between the agricultural sector and its environmental impacts. This is needed because the pressures to our environment from the continuous resource demands of the agricultural production in addition to a rapidly changing climate puts both the environment and the continued delivery of affordable and healthy food at risk.

Agriculture is a key sector for the European economy, providing food security for all European citizens and livelihoods to a large share. With 10.5 million farms across the EU alone, the agricultural sector plays an important role for the rural economy. 44 million jobs in farming and the food sector are dependent on agricultural production. Agriculture also occupies around 40% of European land area.

Enough and clean water is an essential production resource for agriculture, yet pollution from nutrients and pesticides together with over abstraction continue to be major pressures on Europe's waters, reducing the quality of the resource on which agricultural production depends. Furthermore the demand for agricultural land and water has led to major hydromorphological alterations of Europe's water courses with large consequences for especially biodiversity. These pressures have developed as agricultural yields have increased gradually across past centuries and at an accelerated pace after World War II, and are currently being made worse as climate continues to change. As an example, either water scarcity or excess water may threaten agricultural production. With 500 million citizens around 44 million jobs in Europe depending on continued food production, this can contribute to political and social instability. At the same time the world population is growing, raising the question of how a population of 9.6 billion by 2050 can be fed without completely undermining the environment.

This report recaps the challenges that remain for water management in Europe, in relation to the agricultural sector, the role of European Policies for obtaining a more sustainable development trajectory, but also to some of the more systemic changes that are needed. While a water perspective has been chosen, many of the issues and solutions discussed are relevant also to biodiversity or soils, as well as to climate change mitigation. Agriculture is currently responsible for around 10% of Europe's greenhouse gas emissions.

Due to its strong reliance on water, the agricultural production exerts major pressures to Europe's aquatic environment. The main pressures from agriculture are linked to diffuse nutrient and chemical pollution, water abstraction and hydromorphological alterations. These pressures impact water quality, quantity, ecology, and biodiversity in Europe's rivers, lakes, transitional and coastal water bodies as well as the marine environment. According to an analysis of the second river basin management plans that were reported to the European Commission, by European Member States, the United Kingdom and Norway, only 44% of Europe's surface water bodies achieve good ecological status as required by the Water Framework Directive. In EU-27, only 31% of surface waterbodies achieve good ecological status, and frequently failure to achieve this status was due to pressures from agriculture.



Climate change already impacts European water and agriculture, and this will continue. Precipitation has increased in parts of Europe and decreased in others. The growing season is also getting longer, increasing the water demand of crops, and seasonal variability is increasing. Hence, the pressure on water quantity is expected to be exacerbated by climate change, especially in southern Europe where precipitation is expected to decrease and a very large share of the water resource is already used for irrigation. In other parts of Europe, more precipitation will increase transport of nutrients and chemicals into streams, potentially increasing pollution. It will also increase flood risk and general water logging of soil potentially increasing hydromorphological alterations.

European policies are key for obtaining a more sustainable balance between agricultural production and ecosystem health, especially the interface between the Water Framework Directive, and other environmental and food safety policies on the one side, and the Common Agricultural Policy measures on the other. It is critically important that these policies are aligned to one another to maximise policy effectiveness and coherence.

Most EU regulation targets good farming practices. It includes both specific initiatives towards reducing inputs of nutrients, pesticides, and water, as well as more environmentally friendly land use practices. Incentives and regulations for the uptake of good farming practices are therefore key to achieving reductions. Incentives have to be attractive to around 10 million farmers in Europe. While opportunities exist for support to uptake of good farming practices, their insufficient uptake and conflicting policy objectives (trade-offs between objectives not properly recognised or regulated) often prevent achieving the desired environmental results. Lack of implementation at national and regional level contributes to those barriers.

Agricultural production is a major component of Europe's food system. It is widely recognised that the current food system is unsustainable due to its large environmental pressures. Sustainability implies not only that Europe's demand for food and nutrition is provided, but also that livelihoods are sustained and ecosystem health is ensured. Otherwise, long-term viability is threatened. Most existing measures address only the activities in the agricultural production. Other aspects of the food system such as global market forces, global consumer demands, the role of the food processing and retailers are also important but they are not yet addressed by policy. The Green Deal Biodiversity 2030 and the Farm to Fork Strategies provide important new targets to increase the share of organically farmed land and promote more balanced nutrient management. They also advocate the need to influence consumer preferences towards more sustainably produced choices.

It will be a considerable challenges in coming years to develop a food system that balances demand for food and nutrition, while sustaining and ensuring ecosystem health. This report points to some of the aspects that need consideration to achieve this.



# 1 Introduction

This report was initiated following the EEA 2018 European waters: status and pressures 2018 to highlight the role of agriculture in achieving improved status of surface and groundwater in future river basin management plans (EEA, 2018c). The EEA five yearly State of the environment assessment, further highlights the need for an increasingly systemic approach to overcome environmental challenges and to achieve sustainability.

In this report it is analysed how agricultural production affects water quality, quantity and aquatic ecosystems, as well as the relevant policy interventions. With the aim of addressing how the water-agriculture-food system could be better managed, the work is organised around two guiding assessment questions:

- How does the current system of managing agricultural pressures on water work?
- What is needed to improve environmental outcomes?

Agriculture is an important sector for the European economy, providing food security for all European citizens and livelihoods to a large share. With 10.5 million farms across the EU alone, the agricultural sector plays an important role for the rural economy. 44 million jobs in farming and the agri-food sector are dependent on agricultural production. In 2014-2020 around 38% of the overall EU budget was used for the EU Common Agricultural Policy (EUR 408 billion).

As agriculture covers 40% of Europe's terrestrial area, it is not surprising that agricultural production has a major impact on Europe's aquatic environment. The main pressures from agriculture on water are diffuse nutrient and chemical pollution, water abstraction and hydromorphological pressures. These pressures impact water quality, quantity, ecology, and biodiversity in Europe's rivers, lakes, transitional and coastal water bodies as well as the marine environment (EEA, 2018c). Agriculture also impacts biodiversity, soils and contributes around 10 % of greenhouse gas emissions (EEA, 2019g, chapters 3 and 13). These impacts are not discussed in this report, although they are certainly of equal importance.

## 1.1 Towards good status in Europe's river basins

The reporting of the 2<sup>nd</sup> river basin management plans under the Water Framework Directive showed 44% of EU-27, United Kingdom and Norway's surface water bodies to be in good ecological status or potential, 30% to be in good chemical status, and 74% and 90% of groundwater bodies to be in good chemical and quantitative status respectively (Table 1.1). The second river basin management plans also showed that about one third of EU-27, United Kingdom and Norway's water bodies were subject to significant pressures from diffuse sources, and hydromorphology, whereas 6% of surface water bodies and 17% of groundwater bodies were subject to significant pressures from water abstraction (Table 1.2). It is these pressures that need to be reduced to achieve improved status of water, a process that in many cases is complex as each water body can be subject to multiple pressures. In general, the proportion of water bodies in good status is lower, and the share of significant pressures is greater if only EU-27 is considered.



Agriculture is a major contributor to these pressures. Pressures from agriculture on the aquatic environment are linked to specific farming practices, especially those linked to crops: use of nutrients and water to promote plant growth and pesticides to avoid pests and diseases. The livestock production adds a major Furthermore, a wide range of hydromorphological changes have been made to improve conditions for crops but impacting habitat quality in the vicinity of rivers. As climate changes many of these pressures are anticipated to get worse with increased temperatures and water scarcity. Additional impacts on the agricultural production could become considerable.

Status assessments (11/3/2020)	Good or better (%)	Less than good (%)	Unknown (%)
SWB ecological Status	44	51	5
SWB chemical Status	30	36	34
GWB chemical status	74	25	1
GWB quantitative status	90	9	1

**Table 1.1. Overview of status assessment results in second river basin management plans (EEA, 2018h).**

Significant pressures related to agriculture (11/3/2020)	Surface water bodies (%)	Groundwater bodies (%)
Diffuse sources	33	34
Water abstraction	6	17
Hydromorphology	34	-
Diffuse sources (atmosphere)	32	1

**Table 1.2. Overview of significant pressures in second river basin management plans (EEA, 2018h).**

In the report, the results of the river basin management plan assessments have been supported by a spatial analysis of indicators of agricultural pressures to show the extent of agricultural pressures on water across Europe. Indicators include nitrogen surplus, impact of pesticides, water abstraction and a proxy for hydromorphological pressures, at the scale of functional elemental catchments. These have also been combined into an overview of the cumulative pressures.

Furthermore, pressures from climate change may have considerable additional impact on the agricultural production. Climate change is already influencing availability of water for agriculture by altering the precipitation regimes and by increasing evapotranspiration from agricultural soil although positive effects on agriculture are also experienced due to increased temperatures and prolonged vegetation periods (EEA, 2019a). In the absence of adaptation to climate change, it is expected that major changes in the European agricultural production will take place. Agriculture is one of the most vulnerable sectors and will need to adapt to future climate impacts in order to sustain the level (quantity and quality) of production.



## 1.2 Global change and planetary boundaries

Since WWII, Europe has experienced unprecedented economic growth and prosperity, and together with this a very large growth in agricultural outputs, delivering a high diversity of food at affordable prices across Europe. Unfortunately, this has been at the expense of the environment. In the same period the intensification has been driven by nutrient, pesticides and irrigation water inputs, while very large areas have been drained to increase land area available for agricultural production.

Research increasingly reveals a clear human and climate impact on the global water cycle (Rodell et al., 2018). Ecosystems worldwide are impacted by the emission of nutrients and chemicals from agriculture. Globally, agricultural irrigation exacerbate water stress and lead to groundwater depletion. Recurrent water stress occur in many regions such as the central and western U.S., Australia, India, Pakistan, North-East China and the Sahel.

Today several global planetary limits have been surpassed partially as a consequence of the agricultural production, the altered habitats have led to large declines in biodiversity, and climate change is increasing the uncertainty around critical climatic conditions. For example, phosphate fertiliser is based on a rare mineral, and climate change projections are pointing to larger areas subject to more frequent droughts, reducing water availability also in Europe.

At the same time the global challenge is to feed a population growing from 7.8 billion in 2007 to 9.6 billion in 2050, but without undermining the environment and resources on which food production depends, or jeopardizing food security which encompassing available, affordable, and safe food. To achieve this, more resilient farming systems are needed, i.e systems that are more diverse and require fewer resource inputs.

## 1.3 Policy context

Against this background we describe the system for regulating environmental pressures from agriculture at European level. Agricultural pressures on the water environment is the object of an elaborate set of environmental policies, regulation and standards in Europe. In this regard, particularly important policies are the Nitrates Directive with its standards for nitrogen use in agricultural areas and the Water Framework Directive which requires achieving good ecological and chemical status of surface waters, and good chemical and quantitative status of groundwaters are particularly important. The Marine Strategy Framework Directive builds on the objective of the Water Framework Directive, in particular by requiring that nutrient and chemical pollution is not extended into the sea. These Directives are supported and reinforced by other Directives such as the Environmental Quality Standards Directive, the Groundwater Directive and the Drinking water Directive. Table 1.3 provides an overview of EU policy objectives for surface and groundwater bodies.

The watershed represents a fundamental unit for surface water. Within it, water quantity can be accounted for. Watershed land use activities linked to agriculture, forestry, or urbanisation, influence hydrology, nutrient and pesticide inputs, sediment input, and landscape properties all have the ability to change conditions in rivers, ultimately affecting one or more of the four status objectives of the Water Framework Directive. This inter-connectedness underlines the importance of considering a watershed as a whole.



This is fully recognised under the Water Framework and Floods Directives; their objectives are managed within river basins which are related to watersheds. Across Europe (EU-27 and UK), roughly 180 river basins have been identified, and for each river basin, a management plan has been developed. The river basins, however, follow national boundaries, sometimes dividing large watersheds into multiple national units. For accounting purposes, watersheds have also been divided into a system of progressively smaller basins, sub-basins and functional elemental catchments (FEC's) (EEA, 2019h).

**Table 1.3. Overview of EU policies and objectives for relevant for surface and groundwaters**

Policy	Policy objectives linked to agricultural pressures on water	Target year
<b>Environmental Policies</b>		
Water Framework Directive (2000/60/EC)	Achieve good ecological and chemical status of all European waterbodies, as well as good groundwater quantitative status (EU, 2000)	2015
Groundwater Directive (2006/118/EC)	Improve groundwater quality in line with the goals of the WFD (EU, 2006b)	2015
Environmental Quality Standards Directive (2008/105/EC)	Defines water quality standards for pollutants of EU wide concern (priority substances) (EU, 2008b)	2015
Nitrates Directive (91/676/EEC)	Reducing and further preventing water pollution by nitrates from agricultural sources (EU, 1991) .	NA
Drinking water Directive (98/83/EC)	Sets standards for drinking water (EU, 1998)	NA
Marine Strategy Framework Directive (2008/56/EC)	Achieve good environmental status of marine waters in the EU (EU, 2008a)	2020
Floods Directive	Assessment and management of floods (EU, 2007)	NA
Bathing water Directive	Measuring and monitoring the quality of bathing water (EU, 2006a)	NA
<b>European Green Deal</b>		
Farm to Fork Strategy	Aims to make food systems fair, healthy and environmentally-friendly (EC, 2020c).	2030
Biodiversity Strategy	Aims to put Europe's biodiversity on a path to recovery with benefits for people, the climate and the planet (EC, 2020d).	2030
A Zero Pollution Ambition for a toxic free environment. (Forthcoming)		2030
New EU climate Law (Forthcoming)		2030
<b>Circular Economy</b>		



Policy	Policy objectives linked to agricultural pressures on water	Target year
Circular Economy Action Plan (COM(2020) 98)	Launches initiatives along the entire life cycle of products, aiming to ensure that the resources used are kept in the EU economy for as long as possible (EC, 2020b).	2030
Sewage sludge Directive (86 / 278 /EEC)	Encourages the use of sewage sludge in agriculture and regulates its use to prevent harmful effects on soil, vegetation, animals and man (EEC, 1986).	NA
Regulation on minimum requirements for water reuse (741/2020/EC)	Sets minimum requirements for water quality of reused water used in irrigation .	NA
Rules on the making available on the market of EU fertilising products (2019/1009/EU)	Sets standards for fertilising products (EU, 2019).	NA
Roadmap to a Resource Efficient Europe	Transformation within a generation – in energy, industry, agriculture, fisheries and transport systems, and in producer and consumer behaviour (EC, 2011a).	NA
<b>Global Policies</b>		
Sustainable Development Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	2030
Sustainable Development Goal 6	Ensure availability and sustainable management of water and sanitation for all	2030
<b>Agricultural Policies</b>		
Common Agricultural Policy, pillars 1 & 2		2013-2020 and 2021-2027
Plant Protection Products Directive (1107/2009/EC)	Rules for the approval of active substances to ensure protection of human and animal health (EU, 2009b)	NA
Directive on the Sustainable Use of Pesticides (2009/128/EC)	To achieve a sustainable use of pesticides in the by reducing the risks and impacts of pesticide use on human health and the environment and to promote the use of Integrated Pest Management (EU, 2009a)	NA
Regulation on organic production and labelling of organic products (EU/ 2018/848)	Principles of organic production (EU, 2018a)	NA



The Water Framework Directive and Marine Strategy Framework Directives require management plans and programmes of measures that reduce these pressures. Achieving those reductions, however, requires consideration of the close link between pressures and the uptake of good agricultural practices. In contrast, the interests of Europe's farmers go beyond environmental protection. They also include securing income and livelihoods of Europe's 10 million farms.

Different elements of the Common Agricultural Policy seeks to address those interests, including support to environmental objectives. In 2014-2020 around 38% of the overall EU budget was used for the EU Common Agricultural Policy (EUR 408 billion). Pillar I (74%) primarily consists of direct payments to farmers securing their stable income and consumers with a stable food supply at affordable prices. Pillar II (23%) is implemented through national rural development programs with a more diverse portfolio of objectives, aiming to improve competitiveness of farming and forestry, to protect the environment and countryside, improve the quality of life and diversification of the rural economy, and support locally based approaches to rural development. More specifically the three stated long-term rural development objectives are fostering the competitiveness of agriculture, ensuring sustainable management of natural resources and climate action and achieving balanced territorial development of rural economies and communities including the creation and maintenance of employment. In the 2014-2020 period Member States allocated around EUR 80 billion in rural development plans for restoring, preserving and enhancing ecosystems related to forestry and agriculture, increased efficiency in water use, and reduced greenhouse gas emissions and carbon sequestration from agriculture.

This funding is relevant because the pressures from agriculture on the environment are linked to specific farming practices, especially those linked to crops: use of nutrients and water to promote plant growth and pesticides to avoid pests and diseases. Furthermore, a wide range of hydromorphological changes have been made to improve conditions for crops but impacting habitat quality in the vicinity of rivers. The production of animals impacts the aquatic environment, especially because animal manure is used as fertiliser, but also because a significant proportion of intensive crop production aims to produce feed. Hence, the specific farming activities have a decisive impact on the aquatic environment. The specific choices made by farmers in terms of crops grown, animal production, and the details of how resources are used in the production all contribute to the environmental impact. Reducing environmental impact also means managing the choices of around 10 million farmers in Europe.

A recent study by the European Commission on the impact of the Common Agricultural Policy on Water (EC, 2020e), drew a number of important conclusions in regards to the current system:

- It was extremely difficult with the data and information available to the assessors to actually pinpoint the effectiveness of policies.
- Cross-compliance instruments (links to ND and WFD and standards for good agricultural conditions of land) target buffer strips, authorisation of water abstraction and discharge of dangerous substances, but member states usually settle for minimum standards
- Although, indirect, greening measures (crop diversification farm biodiversity and carbon sequestration) support achieving water objectives but were not ambitious enough to achieve significant changes in farming practices and hence guarantee the continuation of minimum beneficial practices



- The Common Agricultural Policy is the most important fund for achieving WFD objectives, but inconsistencies arise in the specific implementation, preventing the desired environmental improvements from taking place

The study and its conclusions is important in terms of understanding shortcomings of the 2014-2020 period. However, its analysis also stays within the boundaries of existing policies, it does not address areas for which policy is not in place although they may be important for achieving better solutions.

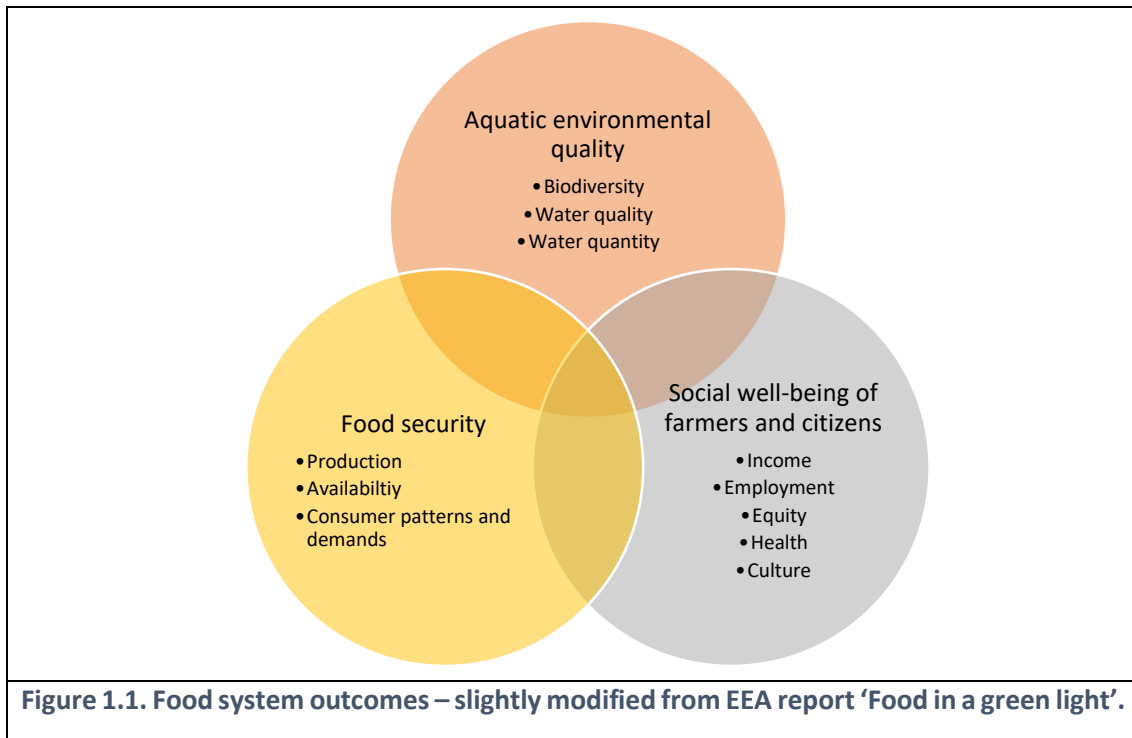
## 1.4 Towards a systemic perspective on water and agriculture

In its 5-yearly flagship report, the European Environment State and outlook 2020, the EEA highlighted the need to take a systems approach to respond to sustainability challenges. Agricultural production is a central component of the food system (**Error! Reference source not found.**) and also the energy system, for instance with the production of bioenergy, and other bio-products. While improvements towards good status are possible through uptake of good farming practices, additional and possibly more fundamental changes can be made by tackling these consumption systems, and addressing some of the indirect drivers on agricultural production.

A sustainable food system is based on three interdependent pillars: the environment, food security, and the social well-being of farmers and consumers alike. Long term sustainable development requires the three pillars to be balanced. The system cannot be considered sustainable if food production takes place either at the expense of the farmer and consumer well-being or the environment.

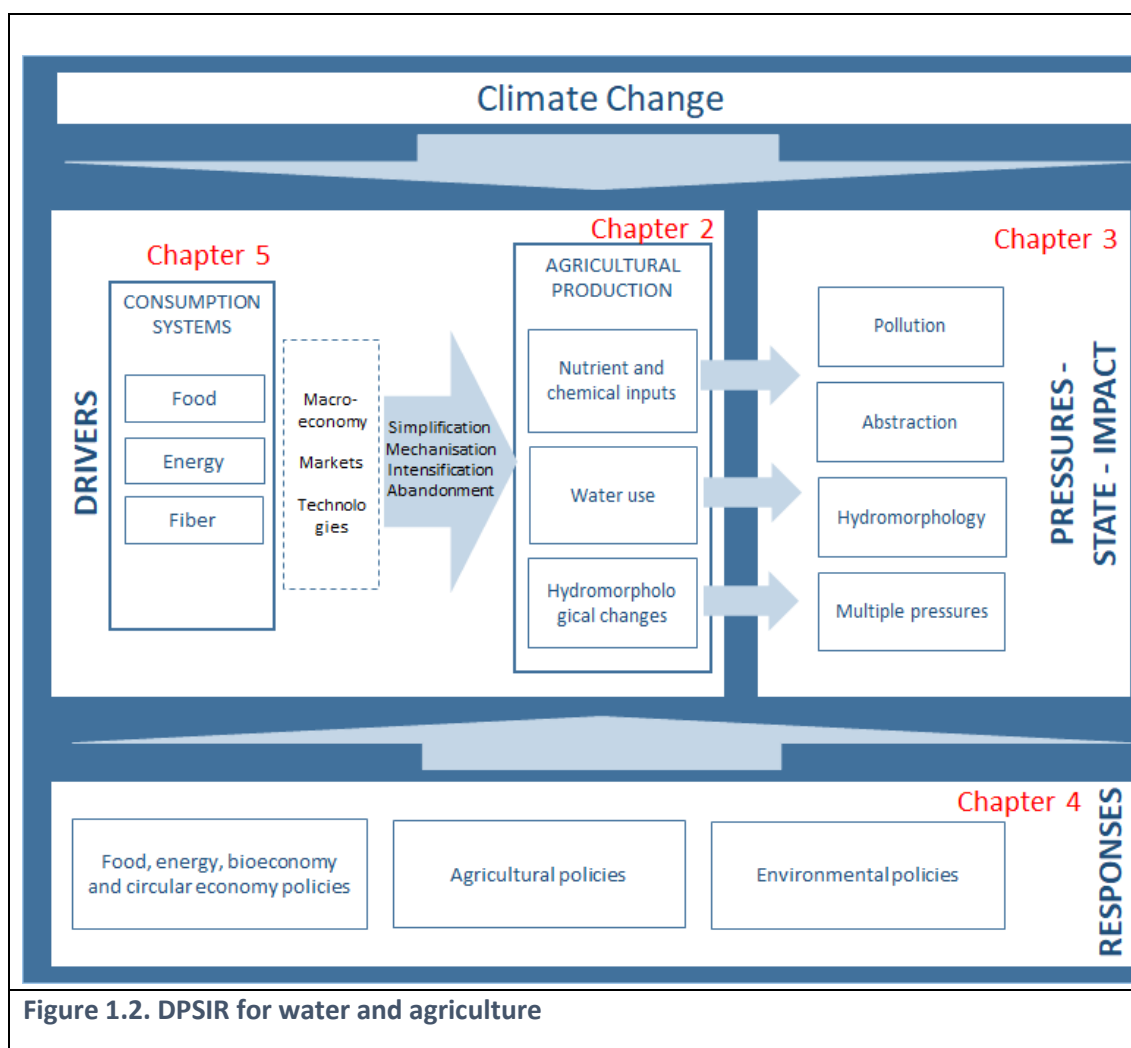
The importance of food and other consumption systems in reaching sustainability is increasingly recognised in Europe. The recent Farm to Fork Strategy for instance attempts to achieve this by influencing consumer preferences towards choices that are more environmental and climate friendly. Studies have shown that environmental pressures could be reduced and human health improved considerably if consumer preferences for meat and dairy products were reduced by 50% (Westhoek et al., 2014).

Food security and sustainable agriculture are key challenges globally and for the European Union. By 2050, the global population is anticipated to have grown to 9.6 billion and delivering enough food in the light of a globally changing climate and environmental resource constraints is likely to become one of the major challenges of the 21<sup>st</sup> century, also in Europe. In Europe and globally, the food system continues to have a key role in supporting European societies, but it also has substantial environmental impact. This report explores in more depth the role of food systems in creating pressures and potential systemic responses.



## 1.5 Outline of report

This report has been organised around a drivers-pressures-state-impact-response (DPSIR) approach to characterise the linkages between agricultural production, pressures on the water environment, their impact on the water environment, and management and policy responses (Figure 1.2). In addition, drivers on agricultural production were expanded to include not only direct drivers of pressures from agricultural practices but also indirect drivers stemming from consumption systems. Chapter 2 provides a brief overview of some characteristics of the agricultural sector, and discusses the intensification that has occurred in the second half of the 20<sup>th</sup> century. Chapter 3 provides an overview of pressures stemming from the agricultural production. Chapter 4 highlights how policy is responding to these pressures, and also characterises aspects of more resilient agricultural practices, and in chapter 5 we discuss the role of the overall food system in driving a more sustainable food production.





## 2 The agricultural sector in Europe

### Key messages

- Agriculture is a key sector for the European economy, providing food security for all European citizens and livelihoods to a large share. With 10.5 million farms across the EU alone, the agricultural sector plays an important role for the rural economy. 44 million jobs in farming and the agri-food sector are dependent on agricultural production.
- Agriculture occupies around 40% of European land area. The yields of the agricultural production has increased considerably in the second half of the 20<sup>th</sup> century, due to increased availability of fertilisers, irrigation and so called land improvements, i.e. drainage. Each of these activities causes environmental impact and when coupled to the large area occupied, those impacts are considerable to water, but also to biodiversity, soils and climate.
- The intensity of the agricultural production is unevenly distributed, with the greatest intensity in western and southern Europe, and lower intensity in Eastern Europe and Scandinavian Peninsula. Roughly half of the agricultural area today is occupied by high intensity agriculture

### 2.1 European agriculture and value chains

#### 2.1.1 *Agriculture in the European economy*

About 10 million farms existed in the EU-27 in 2017, contributing to 1,1% of the European GDP and 4,5% of total employment (equivalent to 8,8 million full time workers) (ESTAT, 2020k). The total value of the agriculture sector lies at around EUR 405 billion in 2018, 53% from crop production and 38,5% from animal products, in particular milk and pigs (ESTAT, 2020k). Agriculture generated economic activity for 280 000 companies in the food and beverage manufacturing industry and 920 000 wholesalers and retailers (ESTAT, 2020k). The food and drink industry itself is an important manufacturing sector in Europe, contributing to form a network of small and medium enterprises including in rural areas. The processing of food nearly doubles the value of the primary agricultural goods, with an estimated value of EUR 860 billion in 2018 (ESTAT, 2020k).

Agriculture provides important functions to the European economy by producing food, fibre, feed and energy for Europe. Agriculture and the food and beverage industry in particular have a central role in EU-27 bioeconomy, representing 78% of its employment and 66% of its added value (Ronzon et al., 2020). Agriculture also contributes to supply the manufacture of bio-based textiles, of plastics and chemicals (including pharmaceuticals), and of liquid biofuels, which accounted together for 4,6% of employment of the bioeconomy and 5,6% of its added value (equivalent to 797,000 workers and EUR 34 billion)(Ronzon et al., 2020).

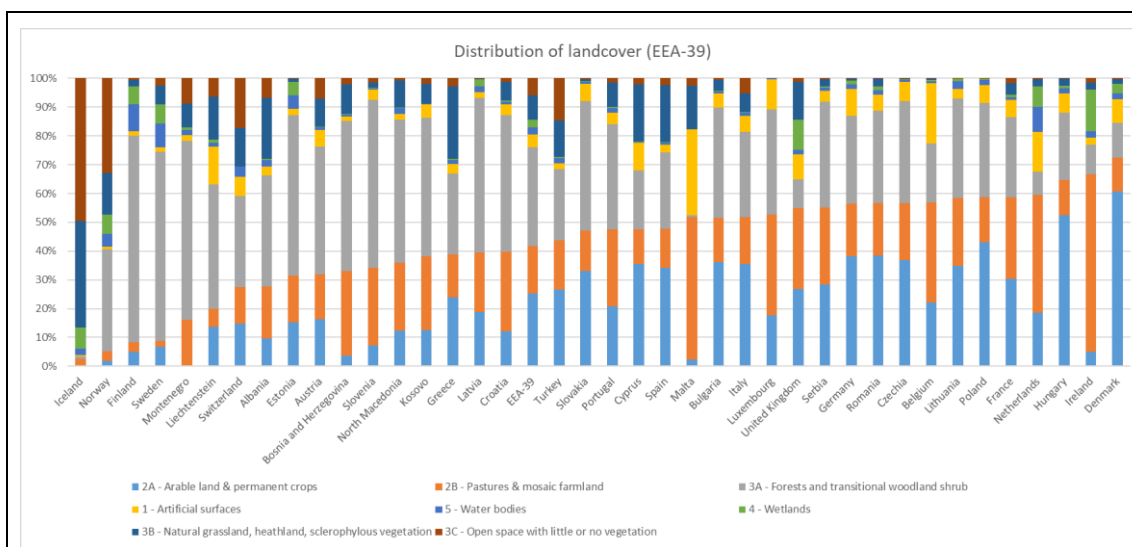
Agricultural goods represent 8% of the EU's international trades in goods (ESTAT, 2020j). The EU is the world's largest agri-food exporter, contributing to 20% of world food and drink exports in 2017. EU international trade in agricultural products has continued to grow, doubling in value since 2002 (ESTAT, 2020j). In value, the EU is a net exporter of processed food and animal products, but it runs trade deficits in vegetable products (ESTAT, 2020j). Large exports include beverages and spirits (e.g. wine from grapes), cereals and cereal products, dairy and meat



produces. In addition to tropical products, the EU mainly imports animal feed and ingredients used in processing such as palm oil.

### 2.1.2 Agricultural land use and production

Agricultural land covers 42% of EU39 terrestrial area or a total of 237 million hectares (EEA, 2019d). Most of the agricultural land is used for arable crops, in particular cereals, and for permanent crops, such as olives, grapes, and fruits (25% of EU39 terrestrial area), the rest being used as grassland and in more complex agricultural landscapes with mixed land uses (17%). The distribution and importance of different land use classes varies considerably between Member States (Figure 2.1). The landscape in countries such as Denmark, Hungary and Poland is strongly influenced by arable crops, which cover more than half of the land area. Ireland, on the other hand, is mainly characterised by pasture farming. In countries such as Sweden and Finland, but also Greece and Croatia, over 60% of the land area is covered by natural land use classes.



**Figure 2.1 Agricultural land use**

Notes: EEA-39

Source: Corine land cover, 2018.(EEA, 2019b)

Agriculture accounts for the majority of biomass supply in Europe. In the EU-28 in 2014, it represented 63% of the total biomass supply, mostly in the form of food and feed to animals, while bioenergy production and biomaterials (e.g. textiles, plastics and chemicals) accounted for respectively 2% and 0,1% of agricultural biomass (Gurria et al., 2017). The market for biomaterial and bioenergy is expected to grow in response to the shift away from fossil-based products. This may lead to increased competition for agricultural goods between the food and non-food sectors, although the use biomass unfit for food and feed consumption, such as crop residues and biowaste could mitigate this impact (EEA, 2018e).

The majority of the EU-28 agricultural output is associated with crop production at about EUR 214 billion (ESTAT, 2019a). The relative importance of different crop production in the EU can be judged using the produced weight of dry matter (Camia et al., 2018). It shows that a large concentration of crop production in few varieties. For the period 2006-2015 in the EU-28, 40% of agricultural biomass was associated to less than 10 crops, mostly cereals (e.g. wheat, maize and barley) and plants harvested green (e.g. green maize, temporary grasses and Lucerne), as well as sugar and starchy crops (i.e. sugar beet and potatoes) and oil bearing crops (e.g.



rapeseed, sunflower). Permanent crops and vegetables accounted for about 6%, while industrial crops, such as fibre flax and cotton, represented 0,2% and energy crops 0,04%.

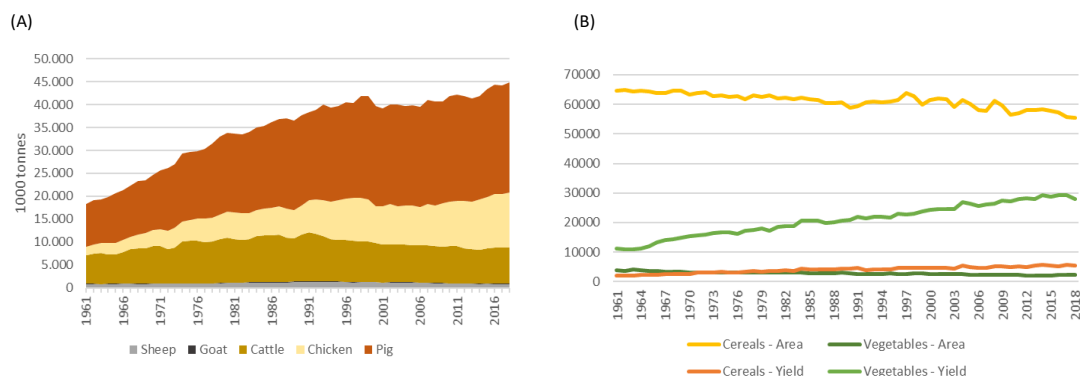
The EU-28 is also major producer of meat and dairy products, with a total output of EUR 156 billion (ESTAT, 2019a). Despite declines in recent years with bovines, sheep and goat populations, livestock units remain significant. In the EU-28 in 2018, pig population was at 148 million heads, followed by bovine animals (87 million), and sheep and goat (98 million) (ESTAT, 2019a). Including poultry, the total production of meat has increased since 2010 to reach nearly 50 million tonnes of carcass weight in 2018, mostly from pig, poultry and bovine animals). The European agricultural landscape is highly influenced by meat production. An estimated 46% of Utilised Agricultural Area (UAA) of EU-28 is used as arable and grass-based fodder areas to produce feed for livestock (ESTAT, 2020b). European livestock production also rely on feed from extra-European countries (see Chapter 5).

### 2.1.3 Trends in agricultural production and land use

It is commonly agreed that current production levels are the result of a long-term post-war policy paradigm based on increasing agricultural productivity, securing food supplies to European nations and increasing the competitiveness of European agriculture on international markets. A combination of structural adjustments and strong market incentives were used across Europe which led to constant growth in European agricultural production until the 1980s (Martín-Retortillo and Pinilla, 2015).

The significance of the growth in European agricultural production can be represented livestock units on the one hand, and area under production together with yields on the other. Figure 2.2 shows that:

- Livestock units in Europe more than doubled between 1960 and 2014 with poultry and pig production showing the highest increases, more than six times and more than twice respectively.
- Cereal production in Europe (EU-28) has tripled, while the area harvested has decreased by about 10%.
- The area under vegetable production has decreased by 44%, while the yield per hectare has more than doubled.



**Figure 2.2: Development of livestock and cereal production in EU-28.**

Notes: (A) Livestock production, (B) vegetable yield and harvest area in Europe, based on EU-28. EU-28

Source: FAO, 2020



Overall, the increase in livestock production slowed in the 1980s due to macro-economic changes, in particular due to oversupply on the European market and changed incentives from the Common Agricultural Policy, including the introduction of milk quotas in 1984 (Martín-Retortillo and Pinilla, 2015). Livestock production continued however to increase in the Mediterranean countries due to the adoption of intensive livestock breeding processes, while it decreased by more than 50% in eastern Europe between the 1980s and 2000s (Martín-Retortillo and Pinilla, 2015).

In contrast, agricultural land has shown a continuous decrease since the 1950s, due to several factors including rural exodus, abandonment of less economically viable farms and increased productivity on land under cultivation (Martín-Retortillo and Pinilla, 2015). Loss of agricultural land is still ongoing, with a total annual loss of agricultural area was about 80,000 ha/year on average between 2000 and 2018 (EEA, 2019d). This loss is primarily to the expansion of artificial surfaces.

In addition to the overall decline in area, a large number of internal conversions also has taken place. A loss of 12% in the area of permanent grassland has been observed in EC-9 between 1975 and 1995, equivalent to a loss over 4 million hectares of permanent grassland (Gibon, 2005). The same area of land could have been used for different agricultural activities during that 18-year period.

The loss of agricultural land since the 1950s has been largely compensated by increases in yields, which overall led to a significant increase in arable and permanent crop production (Martín-Retortillo and Pinilla, 2015). Nowadays average yields in Europe are on average 60% more than the global average (Erisman et al., 2011). Recent years have seen a stabilisation of yields, and in some case a decline (Brisson et al., 2010; Grassini et al., 2013).

#### **2.1.4 Land productivity and the impacts of climate change**

Future agricultural productivity will be influenced by many factors. Some of the key threats include land degradation through soil erosion, land abandonment and soil sealing, and impacts of climate change in particular increased frequency of extreme events such as droughts and heatwaves (Cherlet et al., 2013).

An estimated 17.9 % of agricultural areas and natural grassland, equivalent to 35 million ha, were affected by soil erosion in the EU-27, at an average rate of 3,4 t/ha/year (ESTAT, 2020g). Several countries in southern and south-eastern parts of Europe have significantly higher erosion rates, in particular Italy, Slovenia, Malta, Greece, Spain, Cyprus and Romania (ESTAT, 2020g). Topography and climatic conditions influence soil erosion rates, as are field management practices on arable land and permanent crop areas (e.g. tillage practice soil cover), and livestock density (Vanwalleghem et al., 2017).

The greater use of machinery through e.g. tractors can also lead to greater soil compaction and erosion. Estimates show that the number of tractors per worker has increased from an average of 5 in 1950 to 134 in 2005 in Nordic Europe. Nevertheless, current trends suggest a slight decline in the area affected by soil erosion (ESTAT, 2020g).

Abandonment of agricultural land has been observed across Europe, driven by biophysical, agro-economic, demographic, geographic and macro-economic factors (ESTAT, 2020d). Land abandonment has particularly affected remote and mountainous regions, and eastern Europe following the political changes at the end of the 1980s. Some countries such as Slovakia and Poland have seen decline of 20% of cropland (Keenleyside and Tucker, 2010).

Future projections suggest an acceleration of land abandonment, with about 11% of total UAA of EU-28 at risk of being abandoned (equivalent to 20 million ha) between 2015 and 2030, in particular in parts of Spain, Poland, France, and Slovakia (Perpiña Castillo et al., 2018). In



comparison, it is estimated that the loss of agricultural land to urban areas will concern 0.6% of UAA (Perpiña Castillo et al., 2018).

Impacts of changes in temperature and precipitation is likely to increasingly influence agricultural production differently across Europe (EEA, 2017, 2019a). Increased temperatures might lead to longer growing seasons in northern regions, while further exacerbating water availability and drought events in other regions. Crop yields are therefore expected to increasingly vary from year to year as a result of extreme weather events and other factors, such as pests and diseases, thus increasing the sector's vulnerability to further climate impacts without adaptation (Kovats et al., 2014).

Overall, recent estimates suggest an increase of non-irrigated wheat yields in northern Europe, but a decrease of 12% in southern Europe (Feyen et al., 2020). The same study estimates a decrease of more than 10% of irrigated grain maize yields in southern Europe. Without irrigation, declines of over 20% are projected for all EU countries, with crop losses of up to 80% in some southern European countries.

With regards to livestock, higher temperatures and the increasing risk of droughts are expected to reduce livestock production through negative impacts on grassland productivity and animal health and welfare. The increased growing season for crops and grasslands may boost livestock system production in northern Europe, but across Europe changes in the distribution of pathogens and pathogen vectors present challenges.

In addition, intestinal parasites and insect annoyance may affect animal production negatively. Also, there is a projected increase in rainfall (leading to more flooding) in northern Europe, which may pose challenges for grazing livestock and harvesting grass, owing to the accessibility of land and the declining soil fertility through soil compaction (EEA, 2019a).

## **2.2 Agricultural systems and practices, and their impact on water**

### **2.2.1 *Characterising agricultural systems***

Farms can be characterised as “systems” describing their type of crop and livestock production, the resources and technologies used in their management, the production techniques and strategies - also called “farm practices”- and the nature of relationship of the farm with its biophysical, social and economic environment (NRC, 2010).

Recent debates on the impact of agriculture have sought to distinguish between “conventional” farming and “sustainable agriculture”. Conventional farming systems can be characterised alongside the following (NRC, 2010):

- Crop production is particularly resource intensive e.g. in inorganic fertilisers and synthetic pesticides to increase soil fertility and yields. Crop rotations are shorter and focus on the production of marketable commodities.
- Livestock production benefits from higher stocking densities and may rely on partial or full confinement of animals in housing. Grazing is totally or mostly replaced by harvested forage and grain crops. Veterinary products and other medication such as growth hormones are used to boost productivity.

In a historical perspective, the above practices were widely adopted during the productivist, which effectively secured an increasing supply of food in Europe. The associated intensification of farm practices nevertheless had various impacts on the environment, including aquatic ecosystems (Matson, 1997; Stoate et al., 2009; Ruiz-Martinez et al., 2015).



A large number of terms have been used in Europe to describe different forms of sustainable agricultural systems (Table 2.1). More sustainable farming systems depart from conventional farming practices by adopting more systematically agro-ecological techniques, which aim to optimise the use of natural resources, enhance biological processes in the soil, and improve biomass, nutrient, carbon and water cycles (Wezel et al., 2014; FAO, 2018a; EIP-AGRI, 2020). Sustainable agricultural systems aim to reduce the reliance on off-farm resources and synthetic inputs, and increase their resilience from external disturbances and shocks, such as climate change, notably by diversifying farm activities and production (chapter **Error! Reference source not found.**).

In the recent Farm to Fork Strategy and the Biodiversity Strategy 2030, reference is made to organic farming (Box 2.1) and precision farming (Box 2.2).

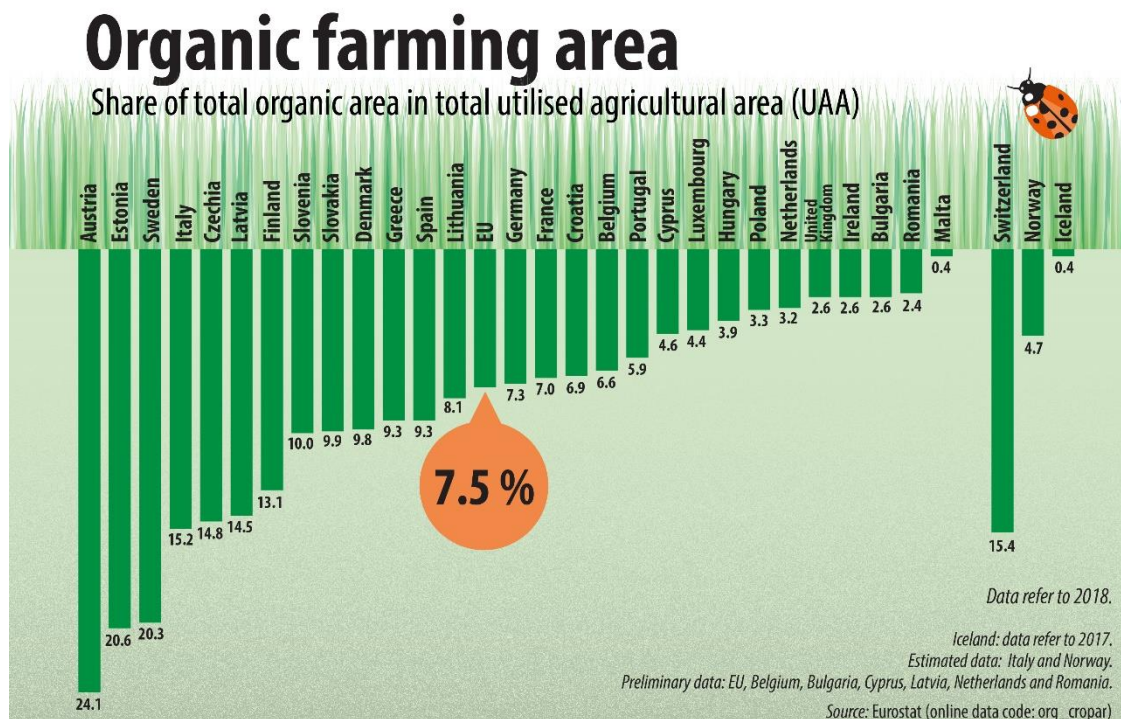


### Box 2.1 Organic farming

The goal of organic farming is develop farming systems that minimise impacts on natural resources (including biodiversity) and which have a high animal welfare. This is achieved by use of natural substances and processes to farm inputs. Organic farmers rely more on management practices which are based on mechanical, agronomic, or biological methods and, where possible, avoid the use of synthetic pesticides, fertilizers or feed. Organic management practices include the use of natural (or naturally derived) substances, diversification and mixing of crops (growing two or more crops on the same plot), complex crop rotation patterns, flower strips and ecological compensation areas and hedges, and a certain tolerance to weed growth that doesn't directly affect the harvest. Thereby natural processes that reduce the growth of unwanted herbivores and pests are supported and natural antagonists are built up, rather than combatting infestations when they have already occurred. Preference is given to crop varieties and livestock breeds which are adapted to local conditions and have a better resistance to pests.

EU regulates the principles of organic farming through comparable standards and stipulates that pre-packaged organic foodstuffs originating or sold in the EU must be labelled with the EU organic farming logo. According to this legislation, organic farmers in the EU may only use authorized farm inputs (EU, 2018a).

In 2018, Organic farming covered 13.4 million hectares of agricultural land in the EU-27 and UK, corresponding to 7.5 % of the total utilised agricultural area. The countries with the highest shares of organic farming were Austria, Estonia and Sweden. In each of these countries the organic share was above 20 % of the total agricultural area (ESTAT, 2020I).



[ec.europa.eu/eurostat](https://ec.europa.eu/eurostat)

With retail sales amounting to 34.3 billion Euro in 2017, Europe is the world's second largest consumer of organic goods EC



Table 2.1 Key terms and definitions related to sustainable farm production systems

<b>Sustainable intensification</b>	is based on the intensification of agricultural productivity while preserving natural and semi-natural ecosystems under future climatic conditions and taking into account social and economic aspects. The increase in production should take place primarily on existing agricultural land, while maintaining and enhancing biodiversity and ecosystem services, using a variety of measures.
<b>Conservation Agriculture</b>	is a farming system which promote minimum soil disturbance (e.g no tillage), permanent soil cover (e.g. mulching) and diverse crop rotation to increase water and nutrient efficiency, increase water infiltration and thus reduce runoff Farmers benefit by the stabilisation of crop production with lower costs for machinery and labour.
<b>High nature value farming</b>	is based on the conservation of biodiversity through continuation of farming with emphasis on extensive management practices (i.e. low inputs, minimum tillage, low livestock stocking levels and landscape elements). HNV farming practices contributes to soil conservation and improvement by minimising disturbance and increasing soil organic matter, thus having a positive impact on water storage capacity.
<b>Agro-ecology</b>	takes into account both ecological and social concepts and principles to optimise the interaction between plants, animals, humans and the environment. This farming concept thus provides the basis for a sustainable and fair food system
<b>Organic farming</b>	aims to preserve natural resources, protect the environment, maintain biodiversity and applies high animal welfare and production standards. This farming system promote measures such as limiting the use of artificial fertilisers, herbicides and pesticides, crop rotation, and the cultivation of nitrogen-binding plants.

### Box 2.2 Precision Agriculture

Precision Agriculture (PA) or precision farming is a management approach based on observation, measurement, and responses to spatial and temporal variability in crops, fields and animals. PA aims to adapt agricultural inputs such as fertilizers, pesticides, water, feed and veterinary medicine to the real-time needs of plants and animals as well as agricultural practices such as tillage, sowing and harvesting to spatial variability. For this purpose a wide range of digital technologies are used including GPS and remote sensing systems, new sensor technologies as well as drones and robots. Rather than applying the same amount of fertilisers, pesticides or water over an entire agricultural field, information on e.g. soil type, soil moisture, nutrient availability and plant health are collected. Decision support systems can analyses the data in order to provide the farmer with precise recommendations.

Therefore, PA can help producing more agricultural output (crop yields and animal performance) with less input (labour, fuel, agrochemicals, anti-biotics, feed) and thus optimize agricultural production in a resource and cost efficient way. At the same time, PA has the potential to reduce the environmental impact on soil and surface water



contamination. With regard to the protection of water bodies and the reduction of water consumption, PA technologies can contribute as follows:

- Automatic machine guidance and section control of sprayers and fertiliser can help to keep fertilisers and pesticides at recommended distances from waterways.
- Automatic steering systems reduce field traffic and thus have the potential to reduce soil compaction, soil erosion and the runoff of surface water, sediments and fertilisers.
- Sensors, remote sensing data and geo-mapping can be used to evaluate soil and crop health and adapt input and farming practices to local conditions. Therefore, these technics reduce the input of fertilizer and pesticides, prevent compaction and erosion and thus reduce the risk of water pollution and sedimentation.
- Robots can help to optimise inputs (fertilisers, pesticides, insecticides) and reduce the impact on soils and water tables. In addition, robots are flexible and able to intervene only where they are needed. This minimizes soil compaction by heavy machines.

With precision irrigation, a precise amount of water can be applied to plants at precise times to optimize crop yield and water productivity. As a result, this technique leads to a reduction in water use. Water metering and measurement of water use can be considered as the basis for precision irrigation. PA can increase profitability for farmer due to increase yields with less input and labour force and furthermore provide farmers with information on the status of crops and animals to improve yield forecasts.

There might also be some disadvantages from the further expansion of PA, especially for small farmers. Compared to large farms, they often lack the investment capital or the knowledge to acquire PA technologies. This can lead to growing competitive pressure between small and large farms, which is expected to reduce the number of farms and increase farm size. Furthermore, the number of jobs on farm holdings is expected to decrease with human labour potentially being increasingly replaced by robots and computers. In some rural areas, the application of PA technologies is still hampered by a lack of suitable IT infrastructure.

Apart from these impacts, PA has a large potential to contribute to the sustainability of the agri-food sector under a growing demand for agricultural products and actively contribute to food security and food safety. PA can contribute to the transparency of the agricultural sector. Monitoring of crops and livestock will allow better predictions of agricultural product quality, making the food chain easier to monitor for producers, retailers and customers. Furthermore, the digitalisation of agriculture makes the environmental impacts more measurable and verifiable and support true cost accounting.

Source: EIP-AGRI, 2015



### 2.2.2 *Intensity of agricultural practices*

Despite the apparent dichotomy between conventional and sustainable agricultural systems, which often dominates public debate, farms are best mapped against a gradient of more or less sustainable farm practices. The intensity of agricultural practices, and their level of can be characterised in several ways (Ruiz-Martinez et al., 2015):

- The use in mineral and organic fertilisers and plant-protection products.
- The extent of irrigated areas and the associated infrastructure such as storage schemes.
- The use of drainage to increase land productivity and reclaim land.
- The level of specialisation in production types, which describes the dominant activity in farm income, and indicates a simplification of production practices.

#### *Use of mineral and organic fertilisers*

Nitrogen and phosphorus are, together with potassium, the primary nutrients and key for plant growth and metabolic processes. Nutrient application on agricultural land contributes to higher crop yields and maintaining soil fertility (Lassaletta et al., 2014). Several techniques can be used to fertilise land, including the use of mineral (synthetic) fertilizers, the use of organic fertilizer, such as manure and sewage sludge, and biological fixation of nitrogen, for example through N-fixing crops such as legumes. Thanks to fertilization of agricultural land, it is estimated that one ha of land in Europe can now feed 4.3 persons as opposed to 1.9 persons in 1908 (Erisman et al., 2008).

The use of mineral fertilizers in the 20<sup>th</sup> century has increased dramatically in Europe (Figure x). It is estimated that the use of mineral fertilizer per ha increased five-fold between the 1950s to the 1980s at European level, with Eastern and Central Europe seeing the largest increase (26 times). Between the 1980s and 1990s, mineral fertiliser use decreased by about 30%, following a drop in the early 1990s with the changed political system but also thanks to a changing policy framework (see Chapter 4). Trends since 2008 do not show any further significant reduction in mineral fertiliser use and consumption has remained stable except yearly fluctuations mostly due to the price of fertilisers (ESTAT, 2020e). This hides large variations between countries.

Currently, Europe is responsible for 12% of the global mineral fertilizer consumption (FAO, 2019), and around 75% of the agricultural area in Europe is fertilized using mineral fertilisers (ESTAT, 2020c). Nitrogen fertiliser consumption per hectare of fertilised UAA currently stand at 77.2 kg per ha (ESTAT, 2020e), with the highest use (above 100 kg/ha) in the Czech Republic, Denmark and the Benelux countries. Phosphorous fertiliser consumption stands at 8,6 kg/ha, with the highest use in southern and eastern Europe, in particular Cyprus, Croatia and Hungary.

The use of organic fertiliser has also increased significantly through the 20<sup>th</sup> century, in particular the use of manure from a growing livestock population (Sutton et al., 2011). The use of manure is higher in countries with a large livestock production. Livestock density varies significantly across the EU (Figure x). Malta, the Netherlands, Belgium, Denmark, Cyprus and Ireland have the highest livestock densities. These countries also show the highest rates of manure input in relation to their agricultural area (over 98 kg N per ha per year) (ESTAT, 2020d). In contrast, Bulgaria, Estonia, Latvia, Lithuania and Slovakia have the lowest livestock densities and also belong to the countries with the lowest rates of manure input per ha (less than 30 kg N per ha per year).

Manure contains also various chemicals, in particular metals such as zinc, copper and in the case of liquid pig manure, arsenic- from livestock-feed additives, and residuals from antibiotics and anti-parasite medicines. Data shows that 40 to 90 per cent of the active ingredients of these medicines are excreted intact by the livestock (Sarmah et al., 2006; Kołodziejska et al., 2013).



Data on other organic fertilisers (except manure) are lacking in many countries and the significance of these fertilisers in agriculture could be underestimated (ESTAT, 2017). For example, re-use of nitrogen from sewage sludge of wastewater treatment plants can be significant. It was estimated that nearly 50% of sewage sludge was disposed on agricultural land in 2011 in the EU-27 (Pellegrini et al., 2016).

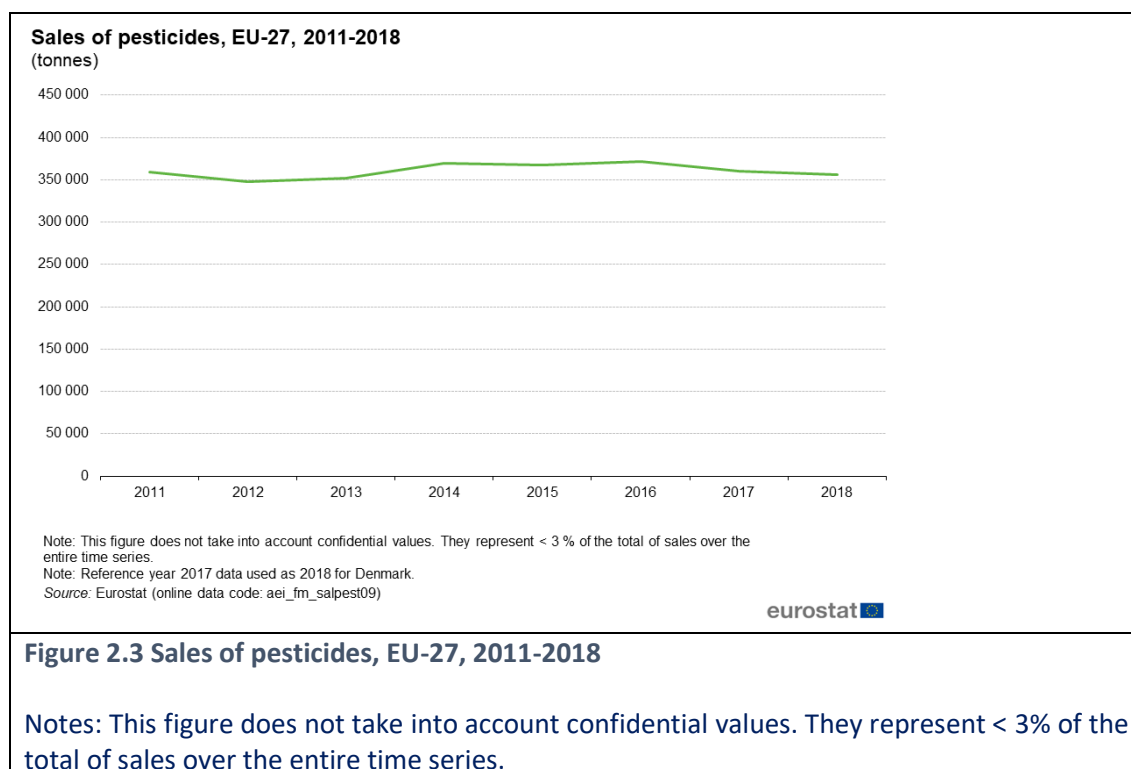
Overall, nitrogen inputs to soils largely consist of mineral fertilisers (45%) and manure input (38%), followed by atmospheric deposition (8%) and biological nitrogen fixation (6%), (ESTAT, 2020c). Mineral fertilisers and manure accounted for more than 93 % of the phosphorus input to agricultural areas in EU-28 between 2010 and 2014. Other organic fertilisers, such as compost, sewage sludge and industrial waste, accounted for little more than 5 % of total phosphorus inputs (ESTAT, 2020f).

### *Use of plant-protection products*

Plant-protection products such as pesticides and herbicides are substances used to prevent or control any pest causing harm during the production of agricultural products. The products contain at least one active substance and have one of the following functions:

- protect plants or plant products against pests/diseases, before or after harvest;
- influence the life processes of plants;
- preserve plant products;
- destroy or prevent growth of undesired plants or parts of plants.

Current information on the application of plant protection products across Europe remains very limited, which is why the total volume sold (or their value) are usually used as a proxy for quantifying application. In the EU-27, the total pesticide sale is around 360 000 tonnes per year (Figure 2.3). This has not changed between time period 2011 to 2018, although significant differences exist between member states with Cyprus, Austria, France and Slovakia showing the highest increase and Portugal, Ireland Czechia and Italy showing the largest decrease (ESTAT, 2020a).





Source: ESTAT, 2020a

### *Irrigated areas*

In Europe, the main crop cultivation period takes place during spring and summer, which typically coincides with a high average water deficit between rainfall and landscape evapotranspiration. Water stress is detrimental to crops when it occurs at critical growth periods, such as flowering, seed formation or ripening. The sensitivity of the crop types to water shortages differs. Some crops can maintain relatively high yields, despite water stress conditions, whereas other crops may fail under similar conditions (e.g. fruits). Some of the most water demanding crops are wheat, barley and maize. Farmers may develop irrigated areas to increase the productivity of their land or as an “insurance” against climate risks, to maintain yields and the quality of crops when rain lacks.

The share of permanently irrigated area in Europe is limited to 2% of land use in Europe (EEA39), and total irrigable area, i.e. agricultural area equipped for irrigation, represents 9% of UAA (in 2016), equivalent to 15.5 million ha (ESTAT, 2019b). The irrigated area - the actual amount of land irrigated - is usually smaller and can vary significantly from year to year due to inter-annual variability in weather conditions, selected crop species to meet market demand, the irrigation strategy of the farmer, and the presence of legal restriction.

Irrigable and irrigated agricultural areas vary greatly among countries mainly because of regional climate and type of production. Overall, crop production in Europe is largely rainfed in the more temperate and humid countries of northern Europe, although irrigation may be used occasionally to complement rainwater. Pockets of intensively irrigated areas exist for example in The Netherlands which has a specialist vegetable and horticulture production. In southern Europe, irrigable and irrigated areas are more widely present, the largest share of irrigated areas compared to their UAA being in Malta, Greece, Cyprus and Italy. Rainfed production is limited to specific crop types, such as wheat, olives, vines and autumn vegetables, though many of these crops are also grown under irrigated conditions in order to increase yields. Irrigation can be an important source of added value in crop production. In Spain, for example, more than 60% of the total value of the country's agricultural output comes from the 14% of irrigated agricultural land.

The area of irrigable agricultural land in some Member States has increased significantly since the 1960s. For example, the area in Italy has doubled and in Spain even tripled. This increase is not the equivalent to the increase in the area actually irrigated. In Spain, for example, the area actually irrigated increased by about 40% between 1990 and 2003 (FAO, 2020). Between 2005 and 2016, irrigable and irrigated areas declined by 3,5% and 6,1% respectively. However, changes are markedly different between countries: the share of irrigable area in the Netherlands increased by 8% while it decreased by 10% in Greece.

Irrigated agriculture often leads to water storage, the construction of irrigation channels and in some cases water transfer between catchments to serve irrigation needs. The countries with the highest percentage of large dams/reservoirs being used for irrigation (as single-purpose or multi-purpose reservoirs) are located in southern Europe (i.e. Cyprus, Greece, Bulgaria, Portugal, Spain, Italy, France), (ICOLD, 2020). Spain has the largest number of large reservoirs in Europe, while Cyprus has the highest density. The majority of dams were developed in the 1960s and 1980s facilitating extensive river water abstraction, mainly for irrigation (Zogaris et al., 2012). These statistics do not include the large numbers of smaller reservoirs used by one or small groups of irrigators. For example, it is estimated that in France alone as much as 125 000 of those existed in 2000 (Carlier et al., 2016a). As droughts increasingly stricken agriculture, the push for creating additional water storage is increasing.



### *Drainage schemes*

Many of the soils of northern Europe are too wet for optimal crop and pasture production. Excess water can result in waterlogging and favour the spread of crop diseases, affecting crop yields negatively. Drainage techniques are used to remove excess water from the soil to lower the groundwater level. Drainage is sometimes used in combination with irrigation techniques for optimal control of soil water content. Across Europe, 17% of arable land area is drained to optimise crop production.

In low-lying areas such as floodplains and coastal areas, much land has been reclaimed for agriculture, often over centuries. Typical situations of land reclamation include the modification of a river with multiple channels into a river with one single channel, or the combination of floodplain drainage with dikes for flood protection. Land reclamation also occurs around lakes, typically by lowering the mean lake water level to gain land for agriculture, forestry or urbanization (Vartia et al., 2018).

In addition, it was common practice in the past to channelize or straighten the streams meandering through agricultural lands. Straightening the channel was mainly done to reduce the wetness of the soil in order to enable an earlier land use and a more profitable land use. Straightening the channel also made the fields more farmable because they could be farmed along a straight waterway. Straightening and sometimes widening and/or deepening of a river stretch is often done in order to maximize drainage surplus water.

### *Farm specialisation and diversification*

The level of specialisation can considerably increase the pressure on water (Le Noë et al., 2018). Specialised regions present less diverse livestock and cropping patterns. Regions highly specialised in livestock production are more likely to have nutrient surpluses because it is not possible to spread all of the manure produced on the farm. In contrast, regions highly specialised in crop specialist may face a nutrient deficit due to lack of available manure, and rely on mineral fertilisers. Mixed farming usually build on the synergies of livestock and crop production to increase nutrient recycling at farm level.

Although diversification can improve synergies between crop and livestock production, it is important to note that the relationship between diversification and use of nutrient or chemical inputs is not straightforward. For example intensively managed diverse crop systems can result for example result in increased use of nitrogen and plant protection products (Herzog et al., 2006).

Overall, agriculture in the EU-28 is highly specialised, with the majority of agricultural holdings are either crop or livestock specialists, respectively representing 52% and 25% of all agricultural holdings (ESTAT, 2020k). Crop and livestock specialist manage 84% of UAA. Only 21% of all holdings are mixed crop-livestock farms, managing 16% of UAA. Since 2005, the share of crop specialists has increased in all but one member states (Cyprus), mainly due to a decline in mixed farming.

At regional level, high levels of field crop specialisation can be observed in parts of Bulgaria, Czech Republic, France, Germany, Poland and the United-Kingdom, while high levels of specialisation in grazing livestock exists in Ireland, Belgium, Luxembourg, the Netherlands, Austria and Sweden, France and the United Kingdom (ESTAT, 2020h). Specialisation in permanent crops exist particularly around the Mediterranean.

## **2.3 A classification of land use systems intensity in Europe**

To illustrate further how agricultural production may exert different pressure intensities onto water resources and provide a basis for exploring the linkages between agricultural production



drivers and pressures (**Chapter 3**), European farming systems were grouped into European Agricultural Regions.

Europe's agricultural production follows broad regional patterns. Freshwater ecosystems also show regional differences in their characteristics and, hence, vulnerability to agricultural pressures. Thus, linking the agricultural production drivers with the pressures from agriculture benefits from a broad division of Europe into major regions: West, East, Mediterranean, North and Highlands, combined (Figure 2.4).

This division integrates the coarse climatic and socio-economic differences between the regions, which influence the agricultural systems. The Western region generally exhibits favourable climatic and economic conditions for productive agriculture, while the Eastern region is characterised by a different structure of farming systems, mainly for historical and socio-economic reasons. Climate-induced water scarcity is the decisive factor in the Mediterranean, and the Northern and Highland regions largely hold less-favourable areas for agricultural production due to wet and cold climatic conditions (Metzger et al., 2005; Kuemmerle et al., 2008; Levers et al., 2018a).

Besides these broad regional differences, agriculture can be separated into different farming systems characterised by type of land cover and management intensity. From a pan-European perspective, the main categories comprise arable and permanent cropland, livestock, extensive grassland and fallow farmland. Management intensity classifies the input expenditures and output revenues, generally separating between intensive and extensive farming systems. Figure 2.4 shows the distribution of different agricultural land systems across Europe, for which the management intensity was quantified combining nitrogen input, livestock density and harvested output (Levers et al., 2018a)



Overall:

- Intensive farming systems cover almost half of the agricultural land in Europe. They feature the highest agricultural yields of common crops across all regions except the Mediterranean.
- The Western region shows the highest share of intensive farming. This region is further characterised by high livestock densities, combined with high yields of plants harvested green for animal feed. Extensive farming covers almost one-third of the agricultural land and generally generates lower yields and livestock products, with the Western region again being the most productive among these land systems.
- The outputs of the different Mediterranean farming systems rank lowest in terms of crop yields and livestock products. Apart from the low production levels of various common crops, this region is characterised by cultivation of vegetables and permanent crops such as grapes, olives, citrus and other fruits.
- Less than 20% of the remaining agricultural land in Europe is occupied by extensive grassland area and fallow farmland, with overall very low production rates.

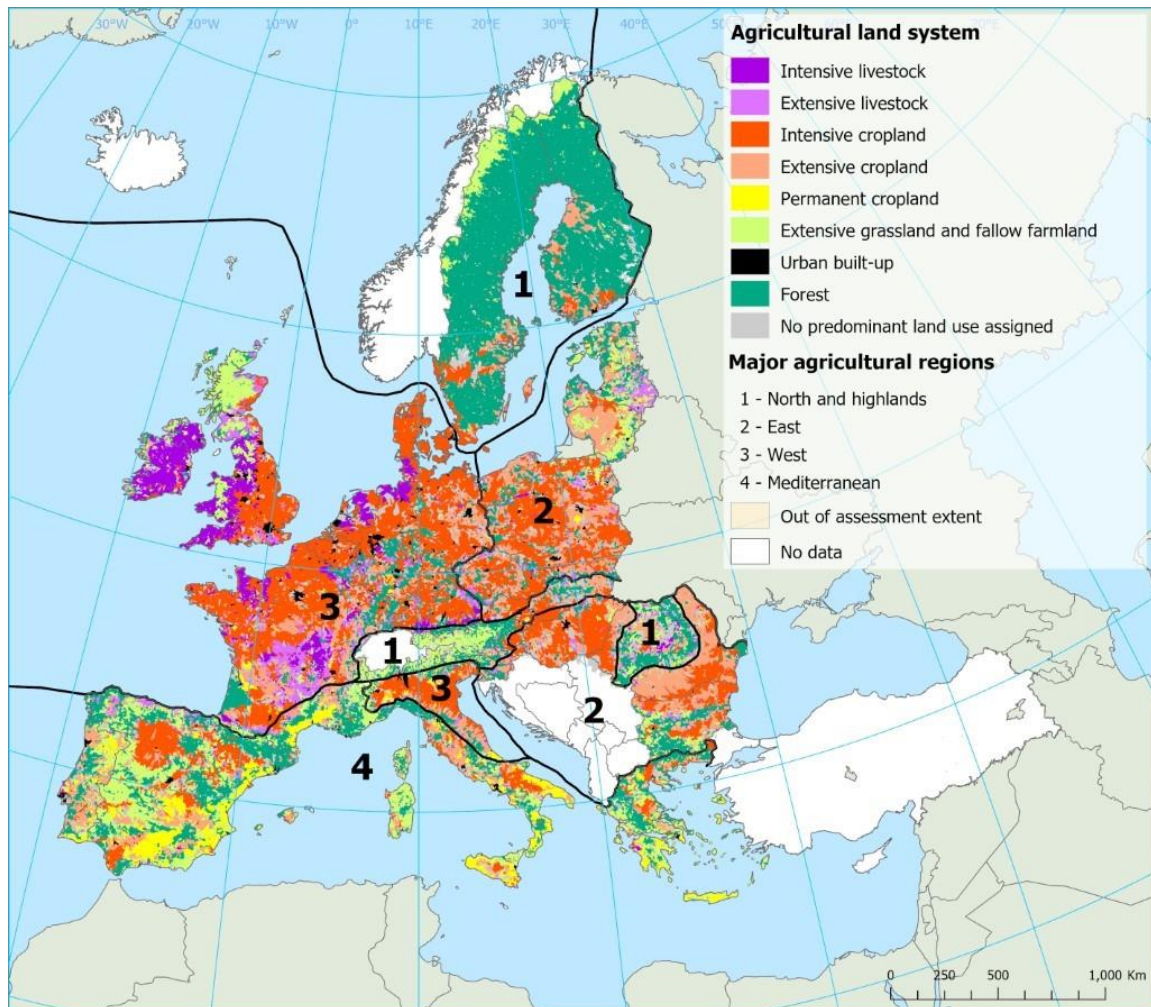


Figure 2.4 Agricultural land systems distributed across four major agricultural regions in Europe.



### 3 Pressures from agriculture to the aquatic environment

#### Key messages

- Currently a large share of surface and groundwater bodies are not achieving good status as required by the Water Framework Directive, in part due to pressures from agricultural activities. Although point source pollution, nitrogen surplus and water abstraction have been reduced, freshwaters continue to be affected by diffuse pollution, water abstraction, and hydromorphological pressures.
- Diffuse pollution of nutrients and chemicals from agriculture remain a significant pressure to one third of surface and groundwater bodies in Europe, and are a main pressure to Europe's seas. Water abstraction for irrigation accounts for up to 80% of water abstracted in in parts of Europe, and water storage, drainage and land reclamation projects are linked to considerable hydromorphological pressures.
- Pressures are not uniformly distributed across Europe, but are higher in Western and Southern Europe, and lower in Eastern Europe. A multiple pressure analysis indicates a relationship between more agricultural pressures and intensity of the agricultural production.
- Diffuse pollution and water abstraction pressures are expected to continue in response to intensive agricultural practices. Climate change increases temperature and alters the supply and demand of water regionally, increasing the need to manage floods and droughts, as well as larger and less predictable seasonal variations. These additional climate impacts exacerbate pollution and abstraction pressures. These changes will impose large additional challenges to manage pressures from water abstraction, nutrients and pesticides, and hydromorphology.
- 

Pressures to the aquatic environment from the agricultural production can be roughly be split into three categories: pollution from diffuse sources, hydromorphological pressures, and from water abstraction. In this chapter, we discuss the status and trends of those pressures together with their impacts.

As part of the second river basin management plans, EU-27, UK and Norway reported on significant pressures to surface and groundwater bodies (Table 3.1). Significant pressures are reported when water bodies fail to achieve good status, and for most pressures the attribution to agriculture is to more than 50% of the water bodies affected.

**Table 3.1: Significant pressures to surface and groundwater bodies as reported by EU-27, UK and Norway in second river basin management plans (EEA, 2018h).**

Significant pressures (11/3/2020)	Surface water bodies		Groundwater bodies	
	Share of total number of waterbodies (%)	Share of water bodies with pressure	Share of total number of waterbodies (%)	Share of waterbodies with pressure



		linked to agriculture (%)		linked to agriculture (%)
Diffuse sources	33	68	34	82
Water abstraction	6	49	17	57
Hydromorphology	34		-	-
Physical alterations		18		
Hydrological alterations		3		
Diffuse sources (atmosphere)	32	Not reported	1	Not reported

Both crop and livestock production are associated with pollution and water abstraction pressures to the aquatic environment. Crop production requires application of synthetic and organic fertilisers, pesticides, herbicides and other plant protection products, as well as irrigation water to support and optimise crop productivity. Manure from livestock production is an organic fertiliser both used as a crop fertiliser and it is spread by grazing animals. In contrast to crops, livestock rearing does not require large inputs of water. Hydromorphological pressures are associated with the over all agricultural activity, where alterations to the natural river has often been made with the aim of optimising the agricultural production.

Soil management operations and cropping practices are important for managing risks to the water environment. Overall, disturbances to soil structure and functions may reduce its capacity for efficient nutrient recycling and natural water storage capacity. Hence, optimising soil for the agricultural production through drainage is a considerable hydromorphological pressure, as is alteration of rivers to enable better water storage for irrigation.

### 3.1 Diffuse pollution

Agriculture is considered a main contributor of nutrients, pesticides and some metals to the aquatic environment (Chapter 2). Other substances, such as veterinary medicines also reach the aquatic environment, but in comparison very little is known about inputs or their impacts. Diffuse pollution of nutrients and pesticides remain a significant pressure to one third of surface and groundwater bodies in Europe, and are a main pressure to Europe's seas.

#### 3.1.1 Diffuse nutrient pollution

Excess nutrient pollution causes widespread environmental and human health problems. Nutrients stimulates undesired plant growth, and can lead to widespread eutrophication of Europe's rivers, lakes, transitional and coastal waters and seas. By causing anaerobic conditions, eutrophication has large impacts on biodiversity. Therefore, the ecological status of water bodies is highly sensitive to nutrient pollution. High nutrient concentration also influences drinking water quality. Excess of nitrates in drinking waters can have human health impacts,



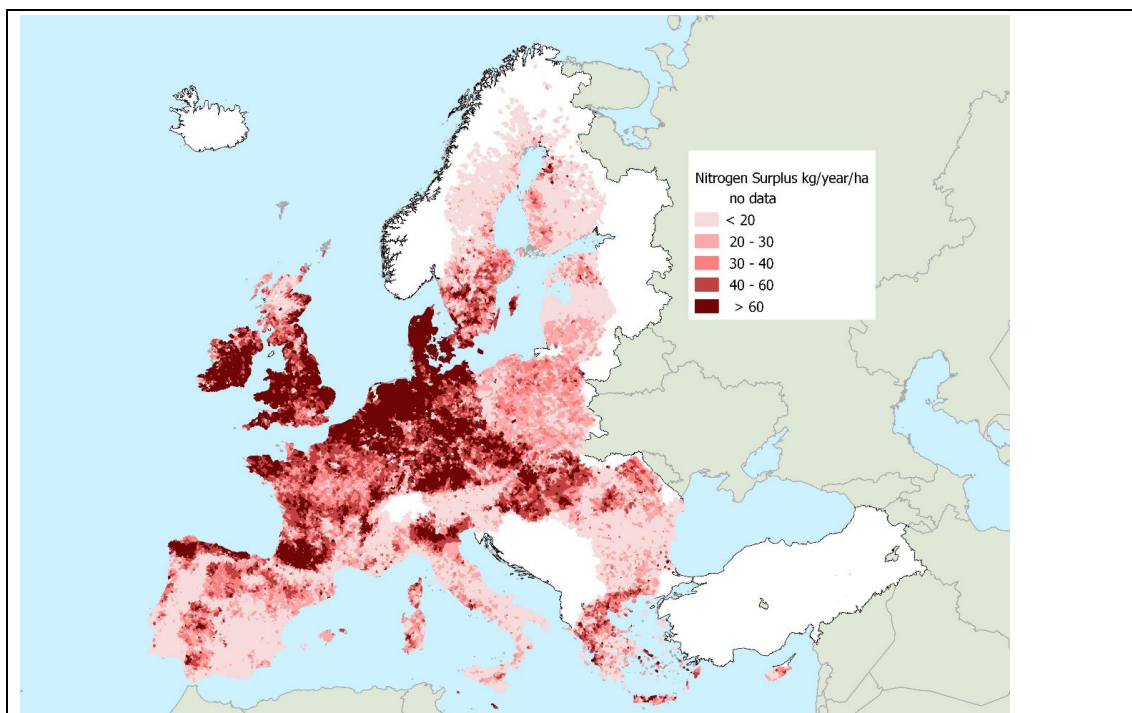
such as methemoglobinemia, which prevents the normal transport of oxygen by the blood to the tissues causing cyanosis (EC, 2018)

In EU, the average nitrogen surplus from excess fertilization of agricultural areas was 49 kg N/ha in 2013-15. It decreased by 10 % between 2004 and 2015, although nitrogen fertilizer use increased during the same period. This is possible because more optimal fertilization approaches are in use, securing that inputs are much more in line with timing of plant uptake, i.e. nitrogen use efficiency has improved (ESTAT, 2017). In the same period phosphorus surplus on agricultural land also decreased from 4 kg P/ha and year to 1.2 in the time period 2004 to 2015 (ESTAT, 2017). As phosphate is effectively stored in soils, a surplus can be reduced without short term impacts on crop productivity (provided that soil is saturated).

As agricultural production is not evenly distributed and agricultural systems also differ widely across Europe, nutrient inputs are also highly variable in space. Here we use the geographical distribution of nitrogen surplus as a proxy for this variability. Nitrogen surplus exceeding 40 kg per hectare/year and which are associated with the most intensive agricultural production methods are located in Central Europe, Germany and the Netherlands in particular, but also in Denmark, the UK and Ireland, and parts of France, Spain, Italy and Hungary (Map 3.1).

The amount of nutrients that end up in streams and the rate at which this occurs, depends crops, specific application strategies, and on a wealth of local geographical factors, such as soil quality and permeability, water availability, groundwater residence times, catchment topography, presence of natural and constructed buffers and wetlands, and climate. Together these factors determine the catchment nutrient residence time. These factors also determine the specific transformations that take place. One of these, denitrification is particularly important as it returns reactive nitrogen (such as nitrate) to the more stable atmospheric N<sub>2</sub>, which may account for considerable nitrogen removal. Ultimately, these processes determine the share of nutrients that end up in rivers, lakes, transitional, coastal waters and Europe's seas.

**Map 3.1 Nitrogen surplus in Europe in 2012.**



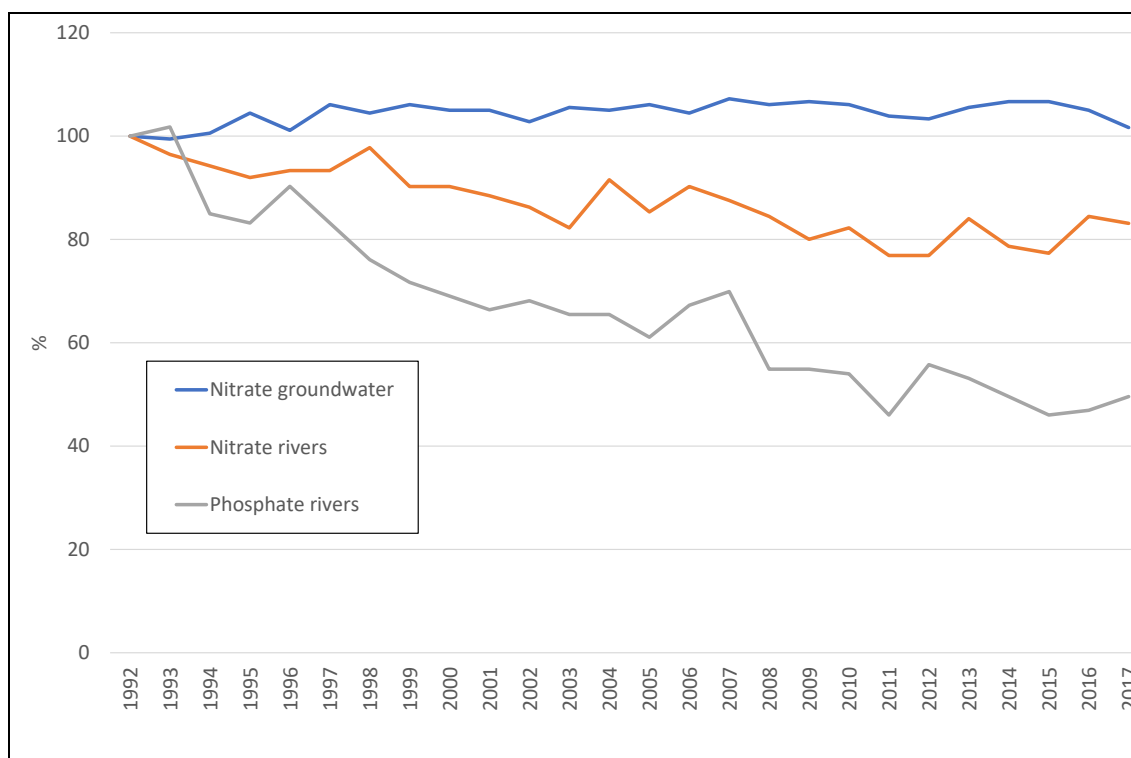


Notes: The CAPRI nitrogen balances were estimated on (1) Export of nutrients by harvested material per crop, depending on regional crop patterns and yields, (2) output of manure, depending on the animal type, (3) input of mineral fertilizers, based on national statistics at sectoral level and (4) a model for ammonia pathways (Leip et al., 2011). Nitrogen surplus on agricultural areas' is a proxy for nutrient pollution pressure, aggregated at FEC-level for the year 2012.

Source: CAPRI (Common Agricultural Policy Regional Impact Analysis) modelling system (Britz and Witzke, 2014) .

In Europe, significant efforts have been made towards reducing point source emissions, and especially the implementation of urban waste water treatment has led to declining concentrations in rivers of phosphate associated with industrial and urban waste water pollution (EEA, 2019c). In contrast, concentrations of nitrates more closely linked to agricultural diffuse pollution are declining much more slowly in rivers and not at all in groundwater (Figure 3.1).

These trends are also reflected in results of the second river basin management plans compiled under the Water Framework Directive. In them, significant pressures linked to diffuse emissions were identified for 33% surface water and 22% of groundwater bodies in EU and Norway, and the pressures in close to 70% of those waterbodies were specifically linked to agriculture (EEA, 2018f). This assessment is made when surface water bodies fail to achieve good ecological status or when groundwater bodies fail to achieve good chemical status. Groundwater bodies primarily fail to achieve good chemical status due to elevated concentrations of nitrates in groundwater.



**Figure 3.1 Trend of nutrient concentration in rivers and groundwater in the EU.**

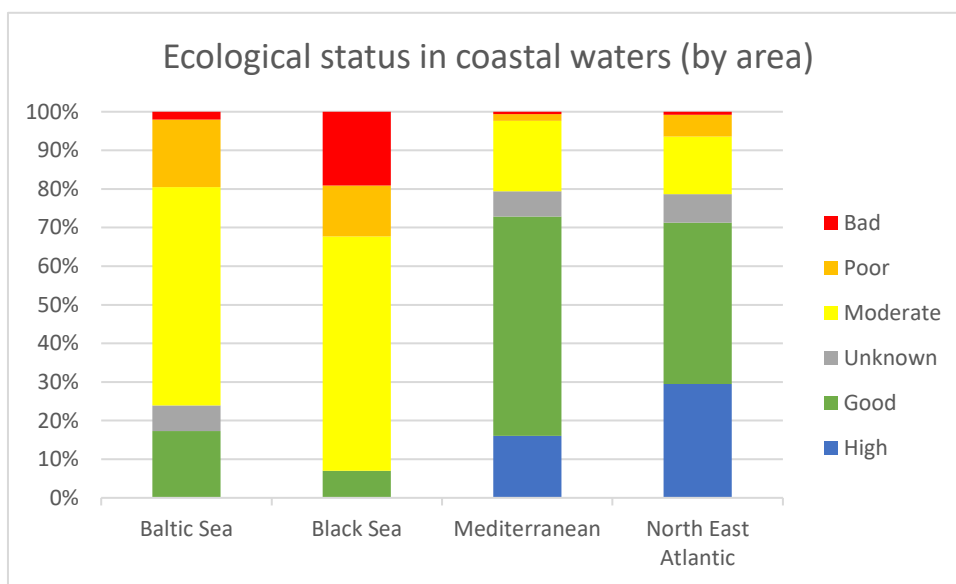
Notes: Concentration in 1992 = 100%; The data series are calculated as the average of annual mean concentrations for groundwater bodies and river stations in Europe. Only complete



series after inter/extrapolation are included; Number of stations included for Europe: groundwater: 552, nitrate rivers: 846, phosphate rivers: 799.

Source:(EEA, 2019f)

Diffuse pollution from agriculture and the associated eutrophication is a major environmental pressure in Europe's coastal waters and seas, especially in the Baltic and Black Seas where only 10% and 15% of coastal waters achieve good ecological status (Figure 3.2). A recent assessment of eutrophication in Europe's seas showed that 99% of the Baltic Sea area, 53% of the Black Sea area, 12% of the Mediterranean area and 7% of the North East Atlantic area were assessed as problem areas with respect to eutrophication (EEA, 2019e). The Baltic and Black Seas are semi enclosed and highly stratified seas with hydrodynamical conditions that hamper water exchange with surrounding water. Both have extensive dead zones as a consequence. The large problems linked to eutrophication in the Baltic Sea has led to international collaboration in context of the Baltic Sea Action Plan, also adopted as a European Regional Strategy (EC, 2009, Box 3.1)



**Figure 3.2. Ecological status in coastal waters, by regional sea.**

### Box 3.1 The Baltic Sea Action Plan

In addition to the obligations linked to the EU Marine Strategy Framework Directive, the Baltic Sea coastal states (which include several EU Member States and Russia) collaborate to specific targets for nutrient emissions as part of the Baltic Sea Action Plan. The Plan was adopted in 2007. It incorporates the latest scientific knowledge and innovative management approaches into strategic policy implementation around the topics of eutrophication, biodiversity, hazardous substances and maritime activities.



Improving the Baltic Sea eutrophication status continues to require reductions in nutrient loads. Nutrient emissions to the Baltic Sea declined by 22% for phosphorus and 25% for nitrogen between 1995 and 2014. Load reductions have primarily been attributed to reductions in point source pollution.

The 2014 assessment indicated that diffuse sources mainly from agricultural activities constitute the major part, making up 46% of the total riverine nitrogen load and 36% of the total riverine phosphorus load to the Baltic Sea. The variability of utilised agricultural area within the catchment is reflected in the variability in contributions. High impact is found in the Gulf of Riga (57% for nitrogen, and 42% for phosphorus), and for nitrogen also in the Danish Straits (68% for nitrogen), and Kattegat (59% for nitrogen).

While these load reductions are considerable they have not been sufficient to achieve the desired environmental improvement of the sea. This is because negative feedback mechanisms in the sea continue to release phosphorus from sea floor sediments during anoxic conditions, slowing down its environmental improvement. Phosphorus in the sea floor stems from historical anthropogenic releases.

Source: (Sonesten et al., 2018)

### 3.1.2 *Pesticides, metals, and veterinary medicines*

The environmental impacts of pesticides and metals are large, and in addition they cause problems for human health through contamination of drinking water and food. Unfortunately, specific environmental impacts are not always well understood.

Soil, with the help of various organisms, filter and buffer contaminants in the environment. Substances that are not readily degradable will eventually leach into surface and groundwaters or be dispersed by wind erosion (Sandin, 2017; Silva et al., 2018).

#### *Pesticides*

Active substances used in both plant protection products and biocides are approved at EU level. EU countries authorize those active substances on their territory and ensure compliance with EU rules. Agriculture is the primary user of pesticides, but they are also used in forestry, horticulture, and in gardens (chapter 2).

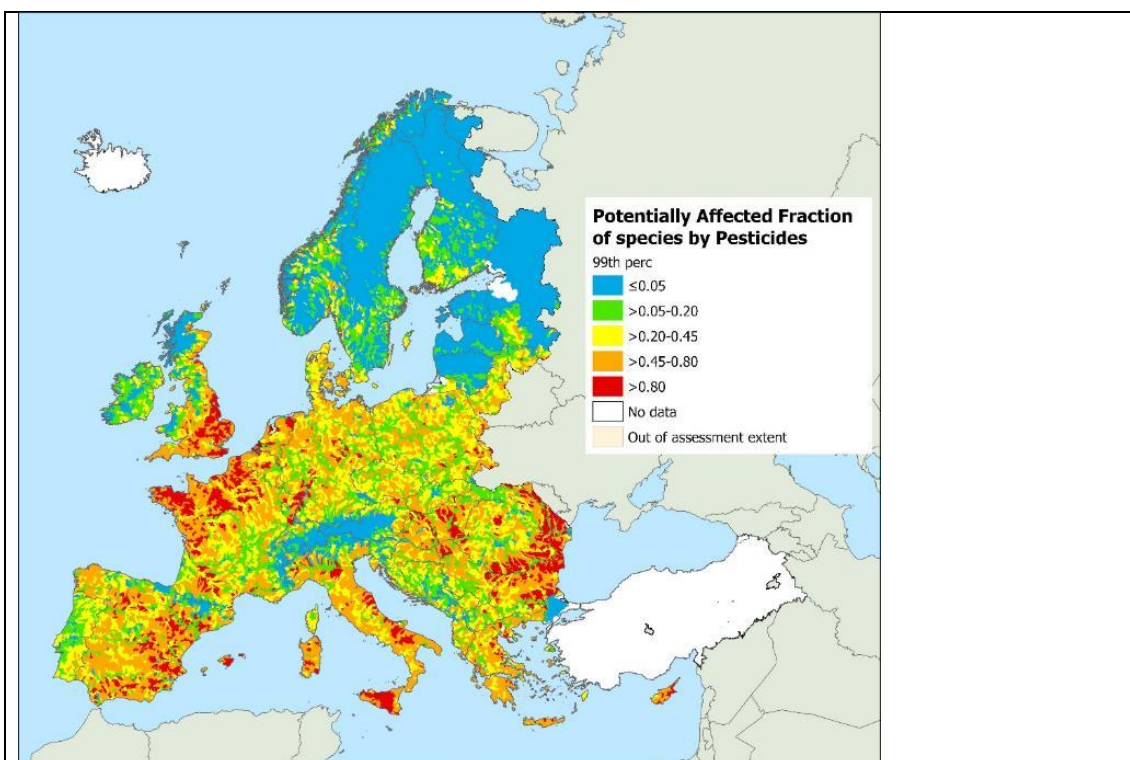
Pesticides can harm the environment by contaminating soil, surface and groundwater. Aquatic organisms are directly exposed to pesticides resulting via surface run-off or indirectly through trophic chains (Maksymiv, 2015). The number of approved active pesticide substances in Europe is around 500 among them around 25% are considered of low risk.

Although pesticides pollution is recognized as a main problem in European countries and many studies have documented the presence of excessive pesticides in the environment, data of European coverage are scarce. According to data reported for the 2nd RBMP under the WFD the number of water bodies exceeding the environmental quality standard (EQS) for pesticides was relatively low; about 160 different synthetic and naturally occurring substances cause poor chemical status in EU Member States. One third of these substances are pesticides. Only a small portion, 806 out of 111 115 surface water bodies fail good status caused by pesticide substances. For groundwater, 370 out of 13 411 water bodies exceed the EQS for total pesticides, equivalent to 3% (EEA, 2018d).



Pesticide substance concentrations reported to the WISE Waterbase, suggest that exceedance rates could be higher than captured by the 2nd river basin management plans. In surface waters, exceedance rates caused by herbicides and insecticides are found for 5 – 15% and 3-8% of observations respectively. For groundwater, exceedances occur mainly for herbicides in 7 % of observations and less than 1 % of observations for insecticides. Fungicides seem to be of lower importance (ETC/ICM, forthcoming).

The heterogeneous reporting of pesticides in Europe are heterogeneous on both temporal and spatial scale means that a quantitative assessment of the risk to the environment must be modelled. To quantify the effects of pesticides on the freshwater ecosystems, the chronic multi-substance Potentially Affected Fraction (msPAF) of aquatic species can be used as a proxy for pesticides pressure intensity (Figure 5). The msPAF specifies the potential share of the biological community affected by pesticide toxicity (van Gils et al., 2019) It has been derived from modelling the cumulative impact of individual substances, aggregated according to their specific modes of action. The highest share of potentially affected fraction of aquatic species is found in western part of France, Belgium, the Netherlands, the north-western parts of Germany, western UK, Spain and Italy, Romania and Bulgaria, Malta and Cyprus. Low values of msPAF, are found in the northern parts of Europe and in alpine regions where agriculture is less intense.



**Map 3.2 Multi-substance Potentially Affected Fraction (msPAF) of aquatic species in European countries**

Notes: Insert notes here

Source: van Gils et al., 2019



### *Metals*

Metals accumulate in and contaminate arable soils. Cadmium, copper, and zinc are among the more common metals. They are linked to different sources of fertilizer.

Cadmium — mainly originating from mineral phosphorus fertilisers — accumulates in 45 % of agricultural soils, mainly in southern Europe where leaching rates are low due to a low precipitation surplus (EEA, 2019g). Cadmium is grouped as a priority hazardous substance in the EQSD, i.e. among the most toxic environmental chemicals. Cadmium is however rarely transferred to water, and is of less concern in water.

Animal manure is the largest source of copper and zinc. The metals are added to animal feed and are introduced into the environment through manure spreading. Because of its bactericidal and fungicidal properties, copper has been widely used as a fungicide spray, especially in vineyards and orchards. Results from the Land Use and Coverage Area Frame Survey (LUCAS) soil sampling 2009-2012 show elevated copper levels in the soils in the olive and wine-producing regions of the Mediterranean (EEA, 2019g). Copper-containing materials are also applied as anti-fouling agents for farm cages and nets (Burridge et al., 2010)

### *Veterinary medicines*

Veterinary medicines reach agricultural soils, surface waters and groundwater directly by grazing animals or aquaculture or indirectly by the use of manure application. The most used veterinary drugs are antimicrobials, antibiotics in particular (Error! Reference source not found.. Modern food animal production depends on the use of large amounts of antimicrobials for disease control, and this provides favourable conditions for selection, spread and persistence of antimicrobial - resistant bacteria and their impacts for biodiversity and human health in the environment (Aarestrup, 2005). Management of these substances is an emerging subject.

#### **Box 3.2 Small stream monitoring on veterinary drugs and pesticides in Europe**

Based on a scientific study, pesticides and veterinary drugs were monitored in 29 small streams and 10 countries of the European Union. The results showed, that all the sampled European rivers included in this investigation were contaminated with mixtures of pesticides and, in most of the cases, with several veterinary drugs at the time of sampling, without a clear national or regional pattern. In total, 103 different pesticides, 24 of them banned in the EU, and 21 veterinary drugs were found in the analysed samples.

Source: Casado et al., 2019



## 3.2 Water abstraction

### 3.2.1 Background

Hydrological regimes are key in maintaining healthy aquatic habitats and the quality of aquatic ecosystems, and their role in supporting the achievement of environmental objectives is fully recognised in the WFD. Agriculture can have widespread impacts on the hydrological regime of river basins and aquifers, by changing land use and altering natural hydrological flows across the landscape, and by increasing abstraction in surface water and groundwater bodies. In addition, irrigation infrastructure often involves the building of water storage (reservoirs) and water transfers.

This chapter focuses on agricultural abstraction pressures, which can play a significant role in exacerbating minimum flows needed for health stream ecology. Unsustainable levels of abstraction can reduce river flow to levels that are critical for water-borne flora and fauna. Reduced flows result in a host of other impacts, from lower dilution of pollutants, to the disruption of sediment and nutrient transport, and alterations to natural habitats conditions, including wetland and transitional waters (Chapter **Error! Reference source not found.**).

Abstraction in groundwater poses several threats too. Groundwater is a crucial source of water for nature, especially wetlands and coastal ecosystems, and for water supply, especially for drinking water. Abstraction in groundwater can deplete aquifers and increasing the risk of pollution and saline intrusion. Abstraction in groundwater bodies may not have an immediate impact on surface water bodies, but it may reduce river base flows in the medium term by reducing return flows into surface water bodies.

### 3.2.2 Current level of agricultural water abstraction

In the 2<sup>nd</sup> RBMP under the WFD, water abstraction for agriculture is reported as a significant pressure on the water environment in 64% of EU-28 countries (18 out of 28) and 44% of RBDs (85 out of 194). The countries with the highest proportion of surface water bodies significantly impacted by agricultural abstraction are Cyprus, Spain, France, the Netherlands, Bulgaria, Greece, Hungary and Italy. For groundwater bodies, Cyprus, Hungary, Greece, Spain, Malta, Italy and France are the most affected countries.

Agriculture abstracted on average 50 km<sup>3</sup> of water between 2008-2017 in the EU-28, which is about 24% of total water abstraction (EEA, 2020a). In the EEA-32, total agricultural abstraction was on average 92 km<sup>3</sup> during that period, with Turkey abstracting on average 40 km<sup>3</sup> of water every year. Most of the water abstracted by agriculture is consumed by the plant or lost as evapotranspiration, and therefore does not return to the environment (Box 3.3). As a result, agriculture is the largest net water user in Europe, accounting for 59% of net water use in the EU-28 (EEA, 2020a).

#### Box 3.3 Accounting for water used in irrigation.

Water abstraction refers to the withdrawal of water from a water source e.g. pumping water from groundwater, harvesting water from a spring, extracting water from a river, lake or reservoir. In contrast, water use refers to net water consumption, which is not returned to the environment in the form of return flows or losses due to evapotranspiration.

In agriculture, unintended losses can occur at all parts of the distribution system. For instance, leakage may occur in the canals and pipes bringing water from the abstraction point to the field. In the field, the efficiency of the irrigation methods and technologies or the meteorological conditions at the time of application will influence losses due to infiltration



and seepage to groundwater, and evapotranspiration rates. Irrigation management aims to reduce these losses.

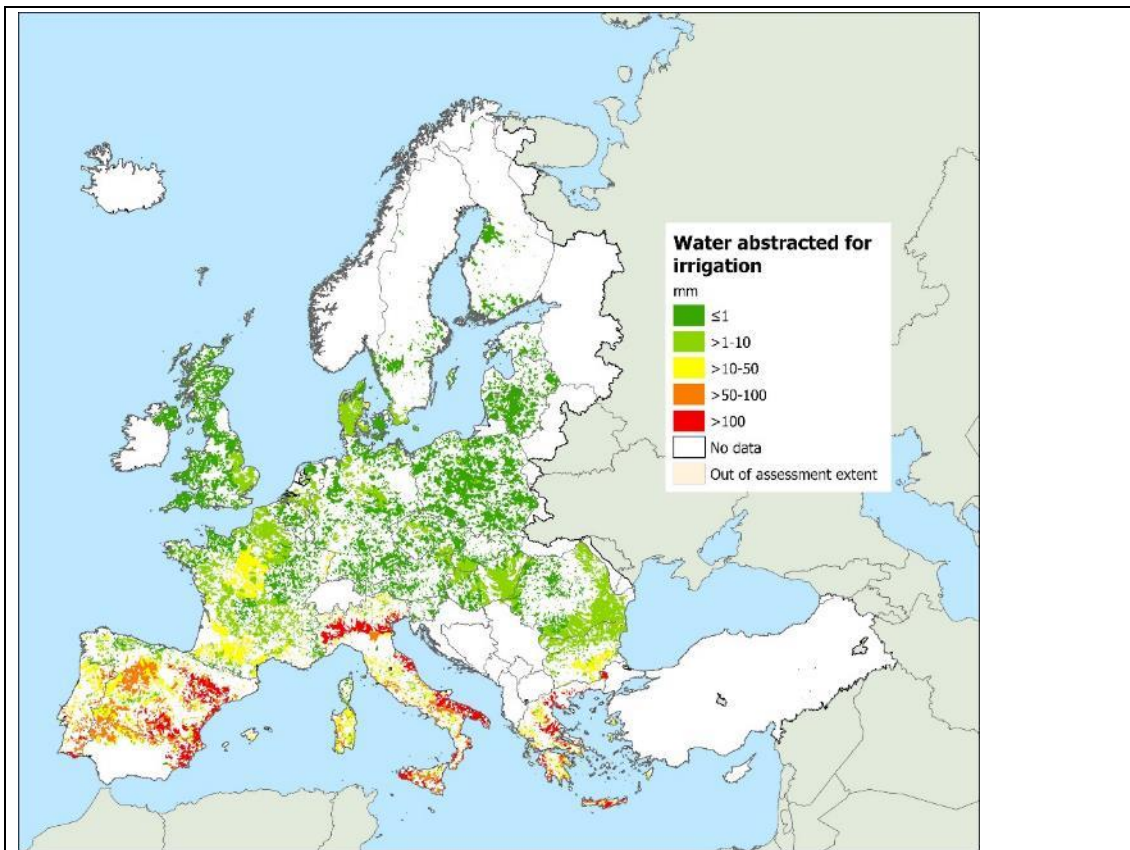
In addition, different crops will have different water consumption intensities. For example, cotton crops water need vary between 7000 and 13000 m<sup>3</sup>/ha while beans water needs are around 3000-5000 m<sup>3</sup>/ha. Water consumed by the crop will not return to the local environment.

In agriculture, a large share of abstracted water is not returned to the environment as it is consumed by the plant or evaporates into the atmosphere. This contrasts significantly with other large water uses in Europe, such as public water supplies, which return most of the abstracted water as wastewater discharges.

Sources: ESTAT, 2020i; Brouwer and Heibloem, 1986

It is estimated that about 50% of water abstracted for agriculture in the EU-28 between 2008 and 2017 is from groundwater bodies (EEA, 2020a). The other half is divided between reservoirs (27%) and rivers (23%). The share of abstraction between surface water and groundwater differs between countries. Groundwater abstraction for irrigation exceeds 50% of total water abstraction for irrigation in Malta, Lithuania, Denmark, Cyprus, the Netherlands, Germany and Portugal. Some of these countries, such as Cyprus and Malta, have more than 50% of their groundwater body area in bad status.

Italy, Spain, Greece and Portugal accounted for 91% of water abstracted for agriculture in the EU-28 between 2008 and 2017 (EEA, 2020a). This is also reflected in an analysis of the spatial distribution of the most intensely irrigated areas (Map 3.3 Annual irrigation abstraction per ha of irrigated land (in m<sup>3</sup>/ha) across Europe in 2015). In those countries irrigation water abstraction levels ranged between 4500-9500 m<sup>3</sup>/ha in 2015. Other Mediterranean countries, such as Cyprus and Malta, present similar high intensities. Bulgaria has the highest irrigation water abstraction intensity (9000 m<sup>3</sup>/ha), while high rates are also found in France, Denmark, Lithuania and Romania (2000-3000 m<sup>3</sup>/ha).



**Map 3.3 Annual irrigation abstraction per ha of irrigated land (in m<sup>3</sup>/ha) across Europe in 2015**

Notes: The annual volume of water abstracted for agricultural irrigation was derived from the EEA Water Accounts Production Database.

Source: EEA, 2020a

### 3.2.3 Trends in water abstraction

Long term statistics on agricultural water use are difficult to recreate given the lack of adequate reporting on irrigation water use before the 1990s. Most studies indicate that water abstraction for agriculture has steadily grown in the second half of the 20<sup>th</sup> century with the expansion of irrigated agriculture (Molden et al., 2007a).

Since 1990, total abstraction from agriculture has reduced in the EU-28, from 80 km<sup>3</sup> in 1990 to 53 km<sup>3</sup> in 2017 (EEA, 2020a). The largest change in the EU-28 occurred in 1990 with the change of political system in Eastern Europe, where agricultural water abstraction has decreased from 8 km<sup>3</sup> in 1990 to 1 billion km<sup>3</sup> in 2017 in Romania and Bulgaria alone.

In total, a fall can also be observed in 16 countries of the EU-28 (EEA, 2020a). Reasons for this evolution are complex and locally specific. In some countries, such as France, it can be associated with the shifts in prices, e.g. favouring less water demanding cereals at the expense of more water demanding maize, as well as stricter abstraction controls imposed by WFD to protect ecosystems during droughts, changes in agricultural policy priorities, or loss of agricultural land to urban area (Martin, 2013).



Some countries have increased agricultural water abstraction such as Belgium, Lithuania and Cyprus. In the EEA-32 countries, Turkey has seen a significant rise in its agricultural abstraction, from 27 billion km<sup>3</sup> in 1990 to nearly 46 km<sup>3</sup> in (EEA, 2020a).

#### 3.2.4 *Unsustainable water abstraction and areas under water stress*

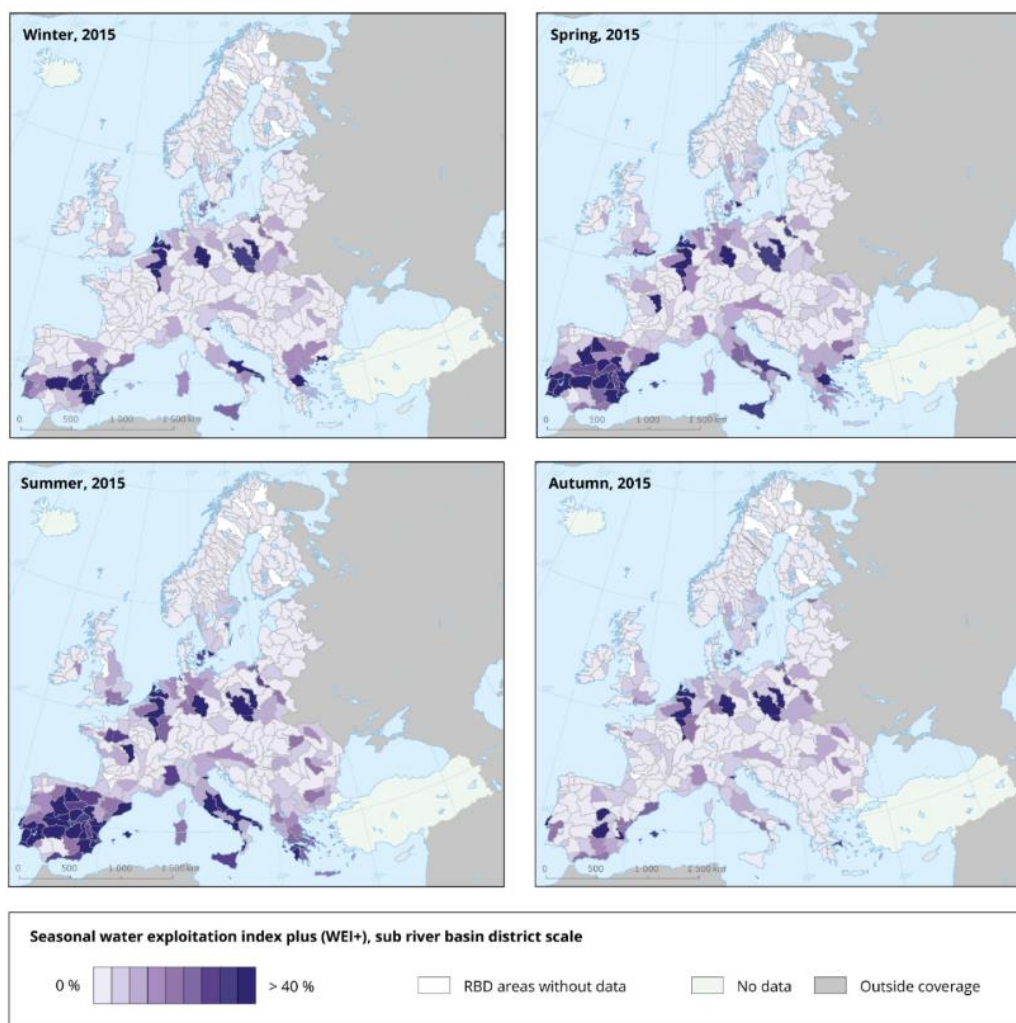
The degree of impact of agricultural abstraction on the aquatic ecosystems depends on the volume of water abstracted, the type of resource exploited, the location of the abstraction point, and the timing of the abstraction, in particular with regards to surface water and groundwater levels and climate conditions. The multiplication of agricultural abstraction points can cumulatively lead to a significant impact on the overall water balance of a catchment or an aquifer, and contribute to water scarcity. It can be particularly impactful on the water environment because abstraction occurs during the dry season when crop water demand is at its highest, while river flows are at their lowest.

Water scarcity is a measure of water availability in relation to human demands. It occurs when the demand for water by different economic sectors exceeds water availability. It is not only related to water demands by agriculture, but to the demand of all sectors that rely on water: households, industry, cooling water and agriculture. These activities are unevenly distributed across Europe, and some have more constant demands whereas especially agriculture has very strong seasonal demands.

Water stress can be used to assess the degree of water scarcity, and is calculated as the imbalance between renewable water resources and water demand. It is expressed by the water exploitation index (WEI+) as the percentage of total water use from surface and groundwater systems over the renewable freshwater resources for a specific area and time. A WEI+ above 20 % implies that a water resource is under stress, and more than 40 % indicates severe stress and clearly unsustainable use of the resource.

The seasonal variation of WEI+ has been calculated for Europe (**Error! Reference source not found.**). Water scarcity associated with agricultural activities have a strong seasonal variation especially evident in southern European countries such as Spain, Italy and Greece. Agricultural water use also contributes to water stress in other regions, where irrigation is developed.

Supporting sustainable abstraction in agriculture and restoring hydrological regimes in rivers and groundwater levels are essential to supporting healthy ecology, enhancing natural resilience to drought, and ensuring that rivers continue to support wellbeing and recreation.



**Figure 3.3 Seasonal water stress in European sub-basins.**

Notes: Water exploitation index results in winter, spring, summer and autumn of 2015

Source: EEA, 2020a



### 3.3 Hydromorphological pressures

#### 3.3.1 Background

Hydromorphological pressures are assessed as part of the Water Framework Directive, requiring Member States to monitor and manage the effects of changes from physical characteristics on surface water body ecology. Hydromorphological pressures are one of the main reasons for failure to reach good ecological status in European water bodies.

Hydromorphology is a term used in river basin management to describe the hydrological (e.g. water flow) and geomorphological processes and characteristics of surface water bodies, which in combination play a key role for aquatic ecosystems, habitats and species. Good hydromorphological functioning, in particular river-floodplain dynamics, is an essential element of ecosystem health and underpins the delivery of many ecosystem services and benefits for society (EPA Catchments Unit, 2016; Houlden, 2018). Especially river-floodplain dynamics are of high relevance for the development of natural hydromorphological conditions (EEA, 2019c). Hydromorphological pressures include physical changes in natural water bodies to control flow, erosion and floods, as well as land reclamation through drainage and river straightening. These pressures are largely responsible for the widespread loss of wetlands that has occurred in past centuries and are linked to many different human activities, including agriculture, urbanisation, energy production and transport.

The physical impact of agriculture on surface water bodies has to a large extent resulted from drainage needed to increase the area of land with conditions appropriate for crop production, and the need to store water for irrigation (Chapter 2.2.3). Impacts include changes in flow, changes to river banks, riparian zones and floodplains, increased sedimentation and disruption of continuity. Flood protection has been installed across Europe, among others to protect agricultural land from damaging floods.

Agricultural activities such as crop cultivation and livestock production impact floodplains and riparian vegetation, when carried out immediately adjacent to the river or in the floodplain. As a result, the edges of many rivers are directly in contact with agriculture and river floodplains have been fragmented and often reduced to narrow strips or isolated trees on the river banks (REFORM wiki, 2015).

Table 3.2 provides an overview of the key hydromorphological pressures and impacts caused by agricultural activities on water bodies and their surrounding floodplains.

**Table 3.2 Hydromorphological pressures from agriculture**

Pressure	Explanation
Drainage	Across Europe, 17 % of arable land area is drained to optimise crop production. Drainage has also been a key element of large historical land reclamation projects. Drainage is one of the most common reasons for designating waterbodies as heavily modified in 2 <sup>nd</sup> river basin management plans. Drainage is done by installing drainage pipes in fields that more quickly



	leads water to nearby streams or drainage ditches. Drainage is related to several hydromorphological pressures including channelization of rivers, channel deepening, increasing the inflow of fine sediments in the water or changing the hydrological regime. A secondary negative effect of drainage on hydromorphology and ecological status is maintenance and operation of the drainage facility (Vartia et al., 2018)
Irrigation	Across Europe, 8% of the arable land area is irrigated. Securing water for irrigation requires water storage and irrigation channels. Dams and impoundments disrupt river continuity as well as migration routes for fish and cause significant changes in river flow and sedimentation patterns (Halleraker, 2016). Irrigation channels secure the distribution of water within a basin, and sometimes between basins. Water transfers between basins to secure water supply for irrigation have significant hydrological and hydromorphological impacts (WWF Deutschland, 2009)
Flood control	Protecting agricultural land from flooding has required the construction of weirs to reduce flow velocity as well as flood defence structures that disconnect rivers from floodplains (EEA, 2019c).
Livestock	Overgrazing and trampling by livestock impact river banks, especially where fencing is inadequate. Overgrazing leads to the loss of riparian vegetation, and trampling damages river bank stability, and leads to increased sedimentation and soil compaction (O'Callaghan et al., 2018).

### 3.3.2 *Current status*

According to the 2<sup>nd</sup> river basin management plans (RBMPs), 34% of surface water bodies across the EU are affected by hydromorphological pressures. Hydro-morphological pressures have been identified in almost all Member States, although to a different extent, with some countries having more than 60% of their water bodies affected. In the majority of countries, between 10% and 60% are affected by hydromorphological pressures and only a few countries have reported a share of affected water bodies lower than 10% (EEA, 2018g).

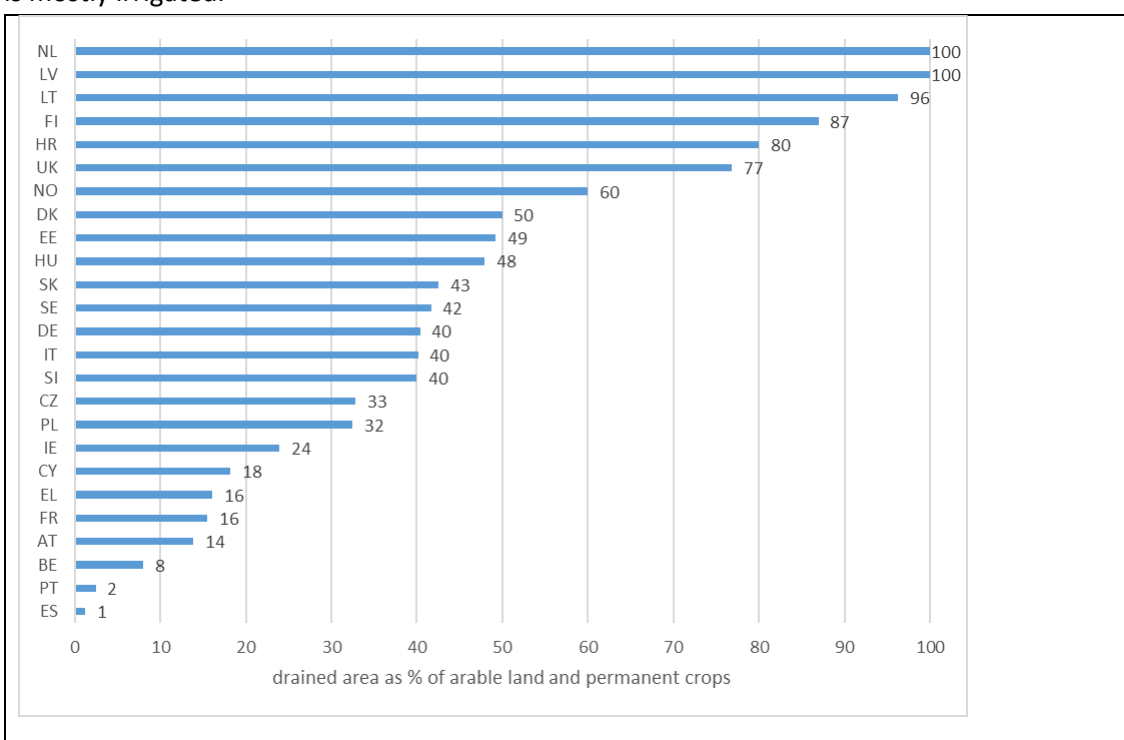
The share of water bodies affected by hydromorphological pressures which are directly linked to agriculture is approximately 7% of total water bodies (EEA, 2018b). The lack of hydromorphological assessment methods and monitoring data appropriate for understanding the nature of hydrological and morphological modifications from agricultural activities, may have led to under estimation of these pressures. Some countries such as Germany, Hungary, Croatia and Spain reported a substantial share of water bodies affected by agricultural hydromorphological pressures, but according to the assessment of the 2<sup>nd</sup> RBMPs by the European Commission, for most Member States, the identified hydro-morphological pressures have not yet been clearly apportioned to specific sectors (including agriculture) in the WFD reporting (EC, 2019a). Nonetheless, awareness of the importance of hydromorphological pressures and impacts from agriculture is growing.

In addition, drainage for agriculture is the third most common reason for designating water bodies as heavily modified in the EU (having led to the designation of ca. 3,700 out of ca. 18,000 heavily modified water bodies in the 2<sup>nd</sup> RBMPs), with the highest numbers being designated in Germany and the UK. An additional 1,500 heavily modified water bodies have been designated



due to physical modifications of water bodies that serve irrigation, with the highest numbers being designated in Spain, Poland, Italy and Hungary (EEA, 2018a).

An overview of the proportion of arable land and permanent crops which is drained is shown in Figure 3.4. Drainage occurs in all countries, but with a strong north to south gradient. In the Netherlands, Latvia, Lithuania, and Finland almost all agricultural land is drained (Herzon and Helenius, 2008). In a high number of European countries, more than 40% of farmland is being drained. E.g. in Denmark, 52% of the agricultural area was drained in the 20th century (Møller et al., 2018). Also in other countries with a large area of arable land, the share of drained land is high, e.g. 77% and 40% in the UK and Germany respectively. (see country details in **Annex**). In southern European countries drainage is lower probably because agriculture in southern Europe is mostly irrigated.



**Figure 3.4 Drained area in European countries as percentage of arable land and permanent crop area**

Source: ICID, 2018

A recent study in Sweden aimed at supporting a national strategy for prioritising measures to improve the water environment in agricultural areas concluded, that a high share of arable land close to water bodies and on their floodplain leads to the impairment of ecologically important structures and functions and degradation of morphology. The result was based on a clustering analysis of sub-basins in Sweden on the basis of agricultural activities. Evidence was provided that sub-basins with a high share of arable land and intensive farming, including livestock, seldom achieve good ecological status while achievement of good ecological status is much more common in sub-basins with a high share of meadows and pastures (Box 3.4)

**Box 3.4 Analysis of agricultural impact on hydromorphology in Sweden**

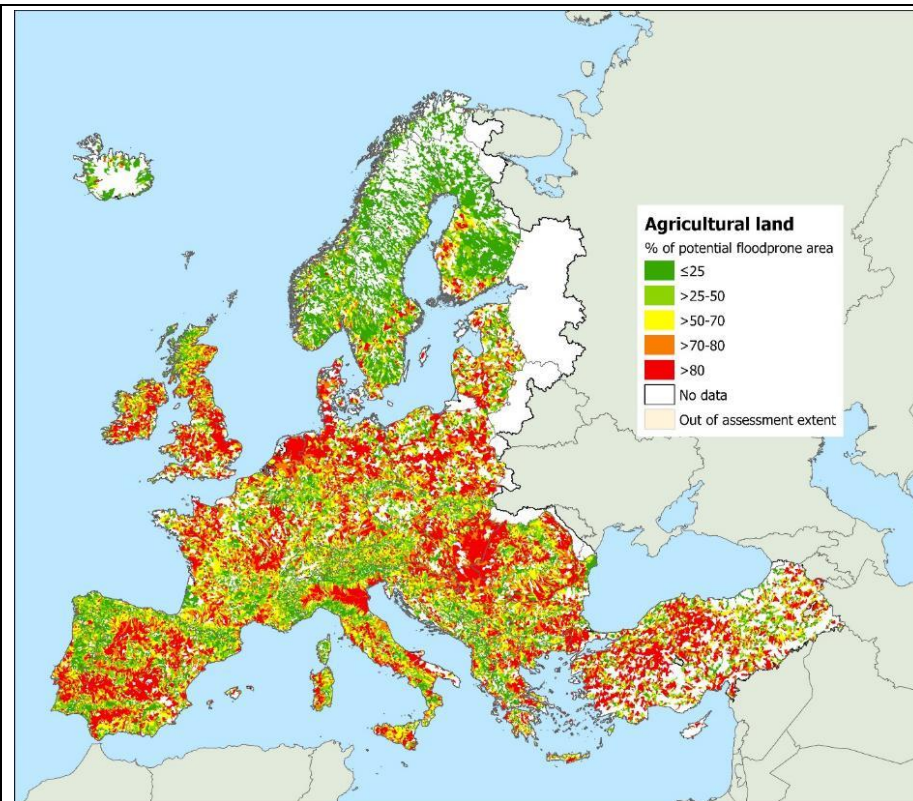
In this clustering analysis, 50.800 sub-basins in Sweden were divided into seven groups based on agricultural values. Three of the seven groups (forest, mountainous areas and wet areas) contain three-quarters of all sub-basins but have almost no agriculture. The other four groups are characterized by a high proportion of a certain type of agriculture: intensive farming with special crops, pig production and laying hens (group 2), meadows and pastures (group 3), rural areas with forestry and agriculture (group 4) and intensive farming with cattle and milk production (group 5). Although the total number of sub-basins in groups 2 and 5 constitutes only 2.7% of all Sweden's sub-basins, the majority of Swedish agricultural production is in these sub-basins (77% of all arable land, 91% of land with special crops, 91% of pig livestock and 84% of laying hens in Sweden). The ecological status of water bodies was compared between these different groups.

Source: Swedish Board for Agriculture and Swedish Agency for Marine and Water Management, 2020.

**3.3.3 *The share of agricultural land in floodplains as proxy indicator***

Agriculture is linked with around 42% of land use activities in European floodplains (EEA, 2019c). Given the lack of EU-wide data availability on the full extent of hydromorphological pressures caused by agriculture, the share of agricultural land in floodplains can be used as a proxy indicator for such pressures. This assumes that the larger the share of arable land and permanent crops in the floodplain, the more an area is likely to be affected by hydromorphological pressures from agriculture, but it does not specify which pressures.

Map 3.4 illustrates that in most functional elementary catchments, the share of agriculture land in floodplains is substantial, especially in lowland areas (medium to high intensity of proxy indicator). The share of agricultural land in flood-prone areas is lower in mountainous regions such as large parts of Scandinavia and the Alps (very low to low intensity of proxy indicator).



**Map 3.4 Geographical distribution of the share of agricultural land in floodplain areas, calculated by functional elementary catchments (FEC)**

Notes: Area of agricultural land located in the potentially flood-prone areas was calculated as an average of the years 2011 to 2013. It was derived from two spatial layers, (1) the JRC flood hazard map for Europe 100- year return period, compiled with the flood model 'LisFlood' (Bates and De Roo, 2000; Alfieri et al., 2015) and (2) the Copernicus Potential Riparian Zone layer compiled with data from the Copernicus Land Monitoring Service (EEA, 2019b).

Four classes of pressure intensity for indicator "Agricultural land use in the floodplain": very low ≤50%; low >50-65%; medium >65–80%; high >80%.

Sources: EEA, 2019b, ETC/ICM forthcoming

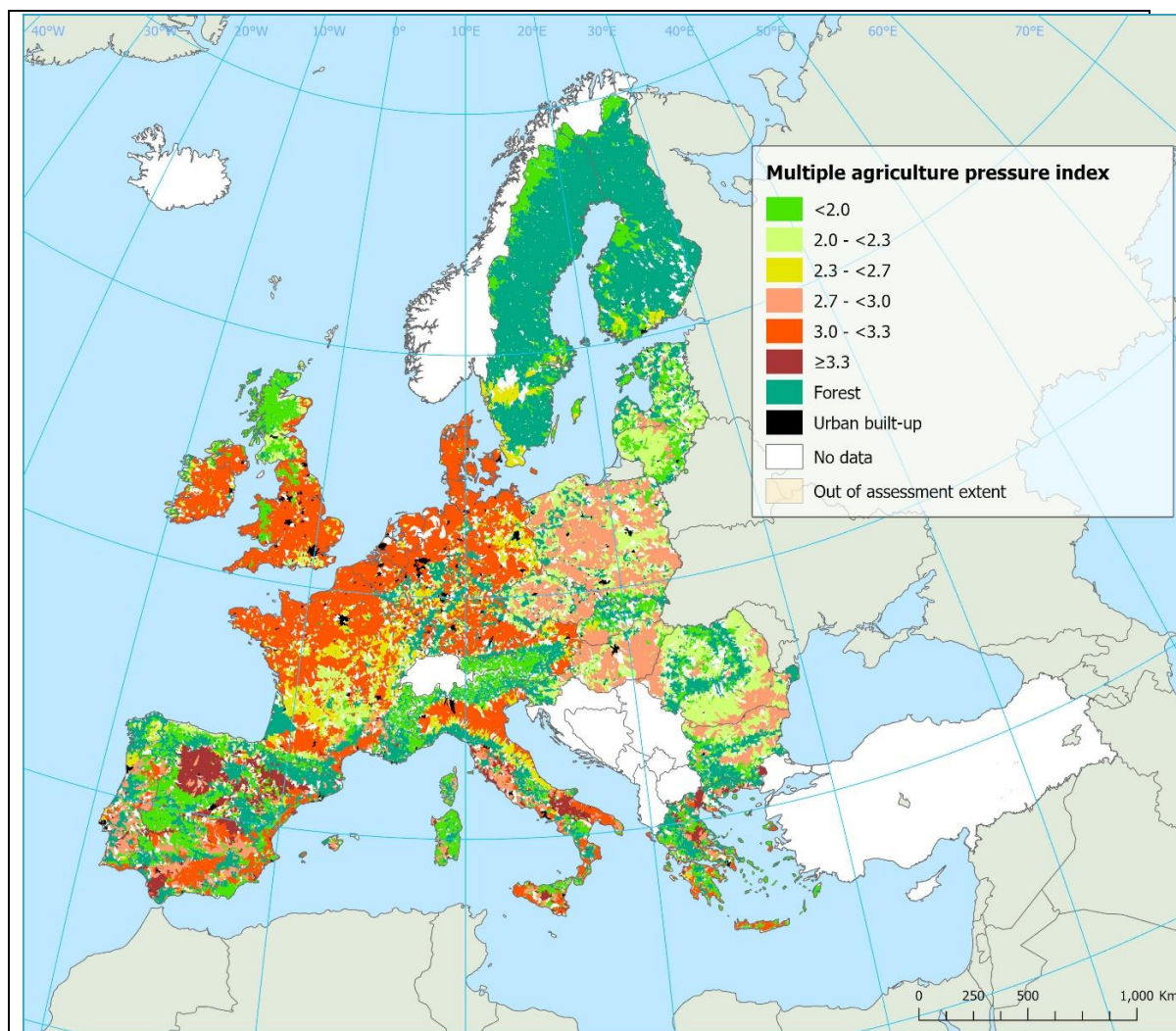


### 3.4 Linking pressures and land use systems

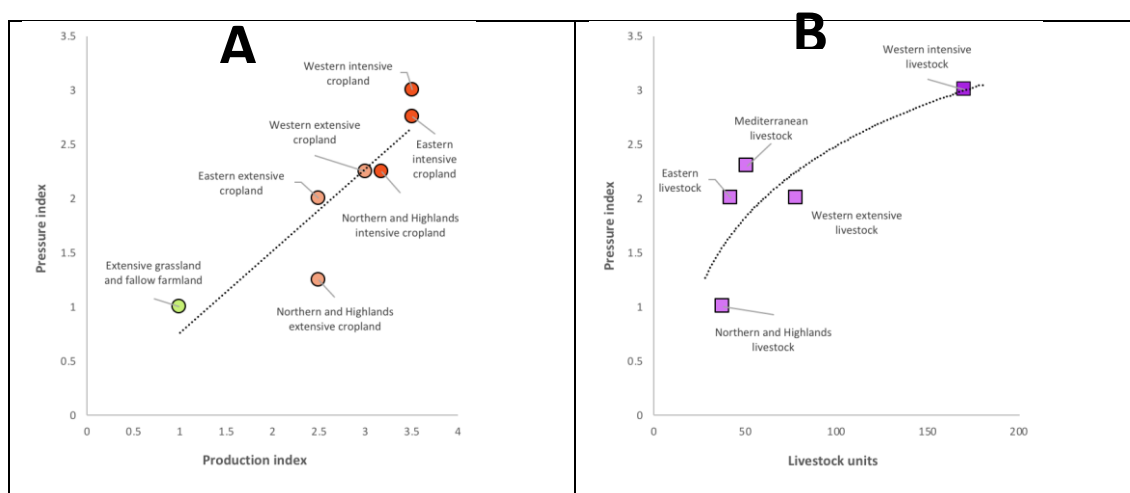
For a continental overview of agricultural production and pressures, data on farming systems, agricultural production levels and agricultural pressures were aggregated at the level of more than 30.000 functional elemental catchments in Europe. Four agricultural pressures were considered: nitrogen surplus, pesticide toxicity, water abstraction for irrigation, agricultural land use in the floodplain (Map 3.1, Map 3.2, Map 3.4, and Map 3.5). This allowed for defining 15 large-scale landscape units of similar agricultural land use and pressures, the so-called “Broad European Agricultural Regions” (BEARs; Schürings et al., unpublished).

The 15 BEARs consider the four major agricultural regions and distinguish between different farming systems (see 3.10). They relate to the dominant agricultural system in the catchment and are characterized by mean levels of agricultural pressures and production, summarised across all catchments belonging to a BEAR. The BEARs show distinct coverage and distribution patterns across Europe: The largest BEAR, for instance, comprises 'Extensive grassland area and fallow farmland', which is assigned to 25% of the catchments dominated by agriculture (Figure 3.7). With 17% of the catchments the BEAR 'Western intensive cropland' covers the second largest area. All other BEARs comprise less than 10% of catchments each.

The mean levels of agricultural pressures and production per BEAR allow for calculating cumulative pressure and production indices. For the pressure index, the mean intensities of the four pressures within each BEAR were ranked and their rank-sums were averaged per BEAR. The resulting multiple agricultural pressure index is shown in Map 3.5. For the production index, the mean yields of six common crops within each BEAR were also ranked and their rank-sums were averaged per BEAR. Both indices illustrate positive relationships between agricultural yields and multiple pressures from agriculture, with farming systems of different management intensities well distinguishable across the gradient (Figure 3.5). Similar patterns are discernible for livestock density and multiple pressures across the five livestock-BEARs (Figure 3.5).



**Map 3.5 Combined agricultural pressure index classifying the average intensity of multiple pressures from agriculture on water bodies in a catchment.**



**Figure 3.5 Relationships between crop and livestock production and pressures.**

**A) Relationship between production index and combined pressure index for the seven Broad European Agricultural Regions (BEARs) dominated by cropland (excluding the**



Mediterranean

BEARs);

B) Relationship between livestock units and combined pressure index for the five Broad European Agricultural Regions dominated by livestock.



## 3.5 Water, agricultural pressures, and climate change

### 3.5.1 *Impacts of climate change on agricultural pressures on the water environment*

Climate change will impact both climatological conditions across Europe (see Introduction) and the productivity of agriculture across Europe (see Chapter 2.1.4). Here, the impacts of climate change on agricultural pressures on the water environment is examined. Complex dynamics are expected between climate conditions, the hydrological cycle and agricultural production. Recent studies indicate that these dynamics will broadly follow different trends between southern and northern Europe. They are examined in turn below.

#### *Southern Europe*

Figure 3.6: Summary of the link between climate change, impacts on agriculture and impacts on the environment/WFD objectives in southern Europe if no transformative adaptation takes place. Figure 3.6 presents the changes in agricultural pressures on water expected for Southern Europe in the short term, if no transformative adaptation in the agriculture takes place.

Increases in temperature will lead to increased evapotranspiration rates, thereby increasing crop water requirements in Southern Europe (EEA, 2019a). This increased water demand will be amplified by more water and nutrients for the same agricultural area and crop in order to maintain crop productivity. This can be explained by the fact that on one hand more water and nutrients are needed to stimulate the longer growth cycle and additional water is needed to secure uptake of nutrients.

Crops that have been rainfed so far will change to needing more water for irrigation (EEA, 2019a). This additional crop water demands will increase water storage demands, lower eflows, or unsustainable groundwater abstraction (EEA, 2018d) impacting hydromorphology of surface waters and ecological status of surface and groundwater status. Overall, it is important to note that the use conflicts of water within the agricultural sector (between farmers) and between sectors (e.g. shipping, energy) are expected to increase.

On the other side most of the processes responsible for soil degradation, including soil organic matter mineralization and erosion, are enhanced by higher temperature and more intense precipitation (Balkovič et al., 2018). Furthermore, the increased temperature can lead to new/increased pests, demanding more pesticides (Lavalle et al., 2009). As stated above this might increase water pollution leading to not meeting good ecological status or deteriorating status further.

**Figure 3.6: Summary of the link between climate change, impacts on agriculture and impacts on the environment/WFD objectives in southern Europe if no transformative adaptation takes place**

Variable	Climate Impact	Impact on agricultural inputs	Pressure	Environmental impact	WFD quality elements impacted
<b>Water quantity</b>	Reduced precipitation overall and in summer,	Increase water demand due to increased irrigation	Reservoir, aquifer and groundwater recharge rates are reduced and over-	Reduction of surface and groundwater levels with negative impacts on aquatic ecosystems	Groundwater quantitative status  Groundwater qualitative status



	Increased temperatures		abstraction takes place	depletion of water depending ecosystem	due to saline intrusion
<b>Nutrients</b>	Increased temperatures	Increased fertiliser demand  Increased water demand to make nutrients available for plants, and reduced water quality	Higher fertilisation rates	Increased nutrient pollution in water, with negative impacts on aquatic ecosystems	Physico chemical QE  Biological QE.  GWB chemical status
<b>Pesticides</b>	Increased temperatures	Increase in spraying of pesticides to combat pest and diseases	Increased spread of pests and diseases. (Impacts on both crops and livestock.)	Increased chemical pollution with negative impacts on aquatic ecosystems	Physico-chemical QE  Biological QE.  SWB chemical status,  GWB chemical status
<b>Hydromorphology</b>	Reduced precipitation overall and in summer,  Increased temperatures	Increase water demand	Increased demand for water storage over-abstraction	Reduced hydromorphological quality and depletion of water depending ecosystem	Hydromorphological QE  Biological QE.

### Northern Europe

Figure 3.7 presents the changes in agricultural pressures on water expected for Northern Europe. Climate change is projected to improve the suitability for growing crops in Northern Europe as a result of a lengthened of the growing season and a decreasing of cold effects on growth (EEA, 2019a). The increased growing season for crops and grasslands may boost livestock system production in northern Europe (Rojas-Downing et al., 2017), leading to changes in the distribution of pathogens and pathogen vectors present challenges. The projected increase in rainfall may pose challenges for grazing livestock and grass harvesting owing to the accessibility of land and declining soil fertility through soil compaction. Depending on the areas available, increased livestock might result in areas with high surplus of nitrogen resulting in lower groundwater quality.

Increased precipitation can lead to increased pressure to drain agricultural land and increase conductivity of streams and rivers, increasing hydromorphological pressures, and reducing ecological status (Abdelbaki, 2015). Also increased precipitation and flooding may lead to increased fertiliser and pesticide pollution due to greater run-off, and reduce capacity for winter crops designed to secure continued nutrient uptake and reduce erosion. Furthermore, the increased temperature can lead to new/increased pests, demanding more pesticides (Laval et



al., 2009). This could decrease ecological status in surface and chemical status in surface and ground waters.

In some areas in northern Europe the increasing drought risks might require that crops that have been rainfed can change to needing water from irrigation (Feyen et al., 2020). This is expected to have negative impacts on ground water bodies.

**Figure 3.7: Summary of the link between climate change, impacts on agriculture and impacts on the environment and WFD objectives in northern Europe if no transformative adaptation takes place**

Variable	Climate Impact	Impact on agricultural inputs	Pressure	Environmental impact	WFD quality elements impacted
Water quantity	Increased precipitation, flood events and frequency, higher temperatures.	None	Flooding	Increased erosion  (agricultural impact: Crop damage and limits to soil workability)	Flood mitigation measures could impact hydromorphological and ecological QE
Nutrients		Due to new crops more fertilizer might be needed	Increased flushing of soils	Increased nutrient pollution	Physico chemical QE  Biological QE.  GWB chemical status
Pesticides		Due to new crops more pesticides might be needed	Increased flushing of soils,	Increased pesticide pollution	Physico chemical QE  Biological QE.  GWB chemical status
Hydromorphology		Additional land will be made arable by draining and straitening rivers	Increased land under agricultural production	Mitigation measures linked to flood defence and increased drainage could lead to reduced ecological status.	Hydromorphological QE  Biological QE.

### 3.5.2 Impacts of climate change on European agriculture and water from a global perspective

Further climate change will affect the distribution of agricultural production on the global level as well and, therefore, food supply and global markets (Porfirio et al., 2018). Even if there are high uncertainties on how global markets will develop there is a common understanding that production patterns will change having also impacts on the EU production (FAO, 2018b).



A cascade of impacts from climate change to agro-ecosystems and crop production, with effects on price, quantity, and quality of the products, and consequently on trade patterns is expected to impact agricultural income in Europe. In the future, the economic value of European farmland may significantly change due to a combination of these cascading impacts. Agriculture intensification could take place in northern and Western Europe, while in southern Europe and especially the Mediterranean a reduction in the relative profitability of agriculture could result in land extensification and abandonment. There will also be areas where the agricultural sector will have losses as the water supply for human consumption will have the highest priority not allowing enough water for irrigation (Godot, 2013), but also to secure e-flows. In such cases, a balance between environmental, social, and economic goals needs to be found (GWP, 2019).

The overall impacts of climate change on European agriculture could produce an important loss for the sector, however with large regional differences. For example, farmers might be adversely affected if a drought damages their crops. They may spend more money due to increasing irrigation costs, drilling new wells, or feeding and providing water for their animals. Industries linked with farming activities, such as companies that make tractors and food, may lose business when drought damages crops or livestock (Cammalleri et al., 2020).

The sector will need to further adapt to these changes to secure sustainable agricultural production. Farm-level adaptation can reduce losses caused by extreme events, but knowledge on all the impacts of climate change on agriculture is still limited, especially when impacts are multiplied or combined with other social-economic consequences of climate change (EEA, 2019a).

EU production could still slightly increase due to the interplay of different market forces. This is because the negative effects in Europe are projected to be lower compared to the other world regions. This provides the EU with a comparative advantage in terms of climate change impacts on agricultural productivity, which could positively affect its competitiveness (Feyen et al., 2020).

On the global level, climate change threatens agricultural production in all parts of the world. Impacts on regional yields can be substantial even in the early decades. The magnitude and exact projected location are nevertheless subject to uncertainty from climate and crop models as well as internal climate variability (Wallach et al., 2015). The long-term yield impacts of climate change more clearly emerge from variability in the middle and end of the 21st century, with considerable variation across regions, and with maize and wheat systems generally more vulnerable than rice and soy (Rosenzweig et al., 2014).

These changes, but also changes in food demand due to a growing global populations and changes in diet are expected to alter the geographic extent of major farm systems, shift trade flows, and drive major investment in adaptation and mitigation within the agricultural



## 4 Managing agricultural pressures on the aquatic environment

### Key messages

- A wide variety of management measures exists to tackle agricultural pressures on the water environment. To date, most measures implemented have sought to improve water management and increase the efficiency of resource use in agriculture. This has resulted in significant improvements and, in some cases, a stabilization in the exponential growth in agricultural pressures observed in the 20<sup>th</sup> century.
- There is significant room for additional environmental improvements from increased resource use efficiency. However, reaching WFD environmental targets will require more ambitious uptake of sustainable agricultural production to reduce total resource use. To achieve this transition, ambitious policies are needed as fundamental changes in the agricultural sector will be required.
- The EU has a comprehensive environmental policy framework, developed over decades, that has contributed to tackle agricultural pressures on the water environment. A lack of enforcement has however impeded their successful implementation. Gaps exist in the policy framework, especially regarding agricultural abstraction and hydromorphological pressures.
- Greater coherence is also needed between EU environmental policies and the sectoral EU policies supporting agricultural production. Recent decades have seen improved integration of water targets in the Common Agricultural Policies. However, future agricultural policies need to be more ambitious on the scale of change needed in production systems. More systematic attention is needed to the ways CAP regulatory and incentive instruments support transition in farming production coherent with environmental goals.
- To achieve a sustainable transformation in the water and agriculture domain, decision-making must be supported by robust knowledge systems from the farm to the EU level. Significant opportunities exist to improve the exploitation of existing data and technologies, and vastly expand our capabilities in monitoring and reporting progress towards sustainability.

### 4.1 Introduction

Environmental pressures to water from agriculture occur as a consequence of the environmental resource demands of the agricultural productions. This demand is regulated through a large number of no regret measures. Such measures are implemented and being tested to tackle agricultural pressures on the water environment, for instance from nutrient (van Grinsven et al., 2012; Schoumans et al., 2014; Ibisch et al., 2016), pesticides (e.g., Carter, 2000; Reichenberger et al., 2007; Lamichhane et al., 2015), water use (e.g. OECD, 2010; Molden, 2007; Chartzoulakis and Bertaki, 2015), hydromorphological impacts (e.g. Flávio et al., 2017; Vartia et al., 2018), including in the context of climate change and the need to adapt and build resilience (e.g. OECD, 2014; EEA, 2019a; Lankoski et al., 2018; Smith et al., 2019). The breadth and variety of management measures, strategies and policies are wide and increases with ongoing research and innovations.



The chapter presents an overview of measures that can be taken at farm or landscape level, their importance for achieving a more balanced and resource efficient agricultural production, while maintaining the integrity of the natural catchment hydrology. Environmental improvements will, however, only be achieved if resource gains are turned into environmental benefits, rather than further increasing the production. Achieving environmental benefits also requires that those measures are implemented by farmers in their agricultural practices. A number of factors influence this uptake and are important to take into account when designing responses. The chapter also provides an overview of the present and upcoming changes to the European policy framework. Environmental policies are first presented, followed by agricultural and rural development policies.

Overall, the European policy framework to tackle diffuse pollution, abstraction and hydromorphological pressures from agriculture is well-developed. However, as will be seen, measures currently taken are not enough to tackle agricultural pressures contributing to the failure to achieve good ecological status. Reasons for this failure includes lack of knowledge, time-lag involved in restoring environmental deterioration, and the need to improve measure uptake (EEA, 2018c; EC, 2019). Additional regulatory action, financial resources and stakeholder mobilisation are also needed to support a more fundamental transition towards sustainability in the agricultural sector. To achieve this, greater integration of water targets in sectoral policies, in particular agriculture, is necessary (EC, 2019a).

The European Green Deal provides a unique opportunity to improve the implementation of existing environmental legislation and raise ambitions on the future environmental performance of agriculture. With their targets on organic farming, high biodiversity landscape features, and reduction in fertiliser and pesticide use, the recently published Farm-to-Fork and Biodiversity Strategies provide the necessary impetus to intensify the transition of the agricultural sector towards sustainability. Reaching these targets will require significant financial and technical resources, and be further translated into existing and new implementing instruments, in particular the future CAP Strategic Plans. The current policy setting is discussed in this chapter, whereas needs for structural reforms of the agricultural value chains to support the uptake of more efficient and agro-ecological principles at the farm level are discussed in chapter 5.

## 4.2 Measures at farm and landscape level

### 4.2.1 *Sustainable water management and farm practices*

**Error! Reference source not found.** presents a consolidated list of water management and agricultural practices that can be used at farm and landscape to reduce agricultural pressures on the water environment. It focuses on measures that are commonly considered more sustainable (Chapter 2.2.1), and offer the potential to increase the resilience of agriculture and rural areas as no-regret measures. They build on the notion that reducing pressures on the water environment should be primarily supported by strategies increasing the sustainability of farming in particular by applying agro-ecological techniques (Chapter 2.2.1). Guiding principles include the need to increase resource use efficiency, increase circularity (e.g. nutrient recycling) and build diversity in agroecosystems to increase resilience, and to exploit ecosystem dynamics and synergies (FAO, 2018a).

Three groups can be distinguished:

- One group aim to enhance the efficiency of resource use in agriculture in order to reduce the emission of nutrient and chemical pollutants and reduce abstraction



pressure, while preserving agricultural productivity. Optimising the use of inputs, through e.g. precision farming, has a large potential to make European agriculture more resources efficient (see Chapter 2.2.1). More efficient resource use is an essential first step in decoupling production from resource use, and reduce agricultural pressures to more sustainable levels.

- A second group of measures involves altering the management of soils, crops and livestock in order to enhance biological synergies and functions and natural biogeochemical cycles, with the overall aim of reducing the dependence of the farm system on external inputs. This is at the core of agroecological practices (Chapter 2.2.1). Hence, the measures highlighted in this group have benefits not only for water management, but also for biodiversity and habitat preservation, as well as for climate adaptation and mitigation (Murrell, 2017; EEA, 2019a; Smith et al., 2019).
- A third group relate to broader landscape approaches contributing to restore a more natural catchment hydrology, creating barriers to nutrient leaching and soil erosion, and reduce hydromorphological impacts on the water environment. This includes landscape elements such as buffer strips and riparian buffers and hedgerows to reduce overland runoff, as well as green infrastructures such as constructed wetlands and sediments to capture subsurface flows and polluted agricultural drainage outflows.

These measures are further discussed in Chapter 4.2. However, efficient uptake of those measures will need to consider the rebound effect, specific contributions of soil and livestock management, and yield reduction.

First, attempts to increase resource efficiency need to avoid that saved resources are redirected to other uses, rather than to reduce pressure. This rebound effect should be avoided if the environmental performance of agriculture is to increase (Box 4.1).

#### **Box 4.1 Investments in water use efficiency in agriculture and the rebound effect**

Increasing production efficiency is an important aim of European policies. Agricultural approaches such as precision farming and sustainable intensification promote more efficient natural resource use. However, resource efficiency improvements do not always translate into resource savings. Instead, some or all of the saved resource may be directed to other uses, offsetting savings and, in some cases, resulting in higher net resource consumption. This is known as the rebound effect or the Jevons' paradox.

In agriculture, there is substantial evidence of rebound effects following investments in efficiency improvements in irrigation infrastructure. Saved water is often redirected to other uses, for instance more water consuming crops or an expansion of irrigated land. The rebound effect may also be led by changed consumer behaviour, resulting in higher demand and resource use.

Although less documented, the rebound effect may also exist for other resources consumed by agriculture, such as nutrients, pesticides or energy use.

Key tools to mitigate the impact of the rebound effect include adopting adequate accounting procedures of resource flows and putting clear limits to resource use at hydrologically relevant spatial scale (river basins).

Sources :Ward and Pulido-Velazquez, 2008; Dumont et al., 2013; Gómez and Pérez-Blanco, 2014; Berbel et al., 2015; Paul et al., 2019



Second, the contributions of specific soil, crop and livestock management measures to reduce agricultural pressures depend on local conditions in soils, climate, slope and other physical, technological, social or economic factors influencing farm management and field operations. Environmental trade-offs may exist. For instance, cover crops may reduce the risk of soil erosion, but they may increase water use and reduce groundwater recharge (OECD, 2014). No-tillage techniques may also reduce risks of soil erosion; however badly implemented, they can lead to soil compaction and encourage the use of herbicides to reduce costs associated with mechanical weeding (Giller et al., 2015). Other trade-offs are of relevance to the overall sustainability of the farm. For example, diversifying crop production at farm level can mitigate financial risks and improve environmental outcomes, but it can also induce higher costs to the farm (Bowman and Zilberman, 2013).

Third, the extensification of agriculture and the adoption of agroecological practices are usually associated with reductions in yields, mainly due to the phasing out of mineral fertilisers (Seufert et al., 2012; De Ponti et al., 2012) and plant protection products (Popp et al., 2013). In Europe, estimates place observed organic farming yields at between 70% (northern Europe) and 81% (southern Europe) of conventional farming yields (De Ponti et al., 2012).

Yield gaps differ largely between regions and crops. The gap is larger for countries which rely on high levels of external inputs, such as the Netherlands and Denmark (De Ponti et al., 2012). Yield gap appears larger for olives, potatoes, leguminous crops and cereals, than for fruits and vegetables (Ponisio et al., 2015). Furthermore, the yield gap between conventional and more sustainable forms of agriculture can be mitigated with careful planning of crop rotations and multi-cropping patterns, and with the development of new crop varieties that perform better in lower intensity farms systems (Ponisio et al., 2015).

Successful implementation of more sustainable soil, crop and livestock management must account the complex and diverse agronomic reality of farming, and adapt practices strategically at farm and landscape level to maximise beneficial outcomes and minimise negative ones, taking into account not only the environmental context but also its social and economic dimensions (Giller et al., 2015).

**Table 4.1 Consolidated list of water management and farm practices**

Group of measure	Technical measures	Mechanisms	Impact on		
			Water quality	water quantity	Hymo
Efficient nutrient use	Improved organic and inorganic fertilization (e.g. control fertilizer use in high risk areas / high-risk times, application on soil/plant conditions)	Improved consumption of nutrients Decreased risk of discharge/leaching	Reduced nutrient loss		
	Manure management (e.g. improved storage and capacity, promote solid manure, incorporate manure into the soil)	Improved consumption of nutrients Decreased risk of discharge/leaching	Reduced nutrient loss		
	Improved inorganic fertilizer (reducing P content)	Reduced emission	Reduced nutrient loss		
	Improved feed (e.g. reducing content of N and P in dairy nutrition)	Reduced emission	Reduced nutrient loss		
Pest and disease management	Improved handling of equipment, scheduling and frequency	Decreased risk of discharge/leaching	Reduced pesticide loss		
	Mechanical control (e.g. hand-picking, housing, hygiene measures, quarantines)	Reduced pesticide use	Reduced pesticide loss		
	Biological controls (predators of pest, more resistant breed)	Reduced pesticide use	Reduced pesticide loss		
Water use efficiency	Improved infrastructure (lining of canals, correct leaking pipes)	Reduced water losses		Lower water demand	
	Water efficient equipment and irrigation scheduling	Reduced water losses	Reduced nutrient loss	Lower water demand	
Soil management	Appropriate machinery and field operations	Improved soil structure Reduced soil water evaporation	Reduced nutrient loss	Improved soil water retention Lower water demand	Reduced sediment load
	Mulching / crop residues	Improved soil structure Increase nutrient recycling Reduced pesticide use	Reduced nutrient loss Reduced nutrient loss Reduced pesticide loss	Improved soil water retention	Reduced sediment load
		Reduced soil water evaporation		Lower water demand	
		Improved soil structure Reduced pesticide use	Reduced nutrient loss Reduced pesticide loss	Improved soil water retention	Reduced sediment load
		Reduced pesticide use	Reduced pesticide loss		
	Reduced tillage / no-till	Improved soil structure Reduced pesticide use	Reduced nutrient loss Reduced pesticide loss	Improved soil water retention	Reduced sediment load
	Contour farming / Terraces / Strip cropping	Reduced run-off/soil erosion	Reduced nutrient loss	Improved soil water retention	Reduced sediment load
	Managing crop water demand (crop selection, drought resistant varieties, timing of sowing and harvesting, deficit irrigation)	Lower water demand		Lower water demand	
Crop management	Improved crop rotation (including diversification, catch crops, cover crops, intercropping, N-fixing crops)	Increase nutrient recycling	Reduced nutrient loss		
		Improved soil structure	Reduced nutrient loss	Improved soil water retention	Reduced sediment load
		Reduced pesticide use	Reduced pesticide loss		
	Conversion of arable land into fallow or permanent grassland	Lower water demand		Lower water demand	
		Lower nutrient demand	Reduced nutrient loss		
		Lower pesticide demand	Reduced pesticide loss		
		Improved soil structure	Reduced nutrient loss	Improved soil water retention	Reduced sediment load
	Silvo-arable agroforestry	Reduced run-off/soil erosion	Reduced nutrient loss Reduced pesticide loss	Improved soil water retention	Reduced sediment load
Livestock management	Reduced stocking density	Improved soil structure	Reduced nutrient loss Reduced pesticide loss	Improved soil water retention	Reduced sediment load
	Livestock fencing	Increased stabilisation of river banks			
	Grassland management (species selection)	Improved consumption of nutrients	Reduced nutrient loss		
	Silvo-pastoral agroforestry	Reduced run-off/soil erosion	Reduced nutrient loss	Improved soil water retention	Reduced sediment load
			Reduced pesticide loss		
Landscape approaches	Buffer strips, field margins and riparian vegetation	Reduced run-off/soil erosion	Reduced nutrient loss	Improved soil water retention	Reduced sediment load
		Increased stabilisation of river banks	Reduced pesticide loss		Improved hydrology
	Hedgerows and wooded strips	Reduced run-off/soil erosion	Reduced nutrient loss	Improved soil water retention	Reduced sediment load
			Reduced pesticide loss		Improved hydrology

	Constructed wetlands, ponds, and sediment traps	Decreased risk of discharge/leaching	Reduced nutrient loss		
		Increased sediment capture	Reduced pesticide loss		
	Improved drainage management (two-stage ditches, vegetation management)	Decreased risk of discharge/leaching	Reduced pesticide loss	Improved soil water retention	Reduced sediment load
			Reduced nutrient loss	Improved soil water retention	Improved hydrology
	River and floodplain restoration (river bed improvements, reduced dredging, re-meandering)	Slow river run-off and increase groundwater connectivity	Reduced pesticide loss		Improved morphology
				Improved soil water retention	Improved hydrology
		Increased stabilisation of river banks			Improved morphology
		Improved consumption of nutrients	Improved consumption of nutrients		



#### 4.2.2 *Other relevant measures at farm and landscape level*

Other farm and landscape measures can contribute to reducing pressures, such as “offline” storage, water harvesting, groundwater use and use of non conventional water resources. They are discussed separately here to highlight their potential contribution to enhance the sustainability of agriculture, if implemented with the right safeguards.

Some countries, such as France, are currently building “offline” storage schemes, i.e. reservoirs are built outside river beds in order to reduce their hydromorphological impacts. They are filled by pumping into water bodies during high flow season (winter) in rivers or shallow, unconfined groundwater, therefore lowering the direct impact of pumping on environmental flows. Storage is only used to substitute summer pumping and cannot result in an increase in irrigated areas. They must be accompanied with metering and the cancellation of the licence to abstract during seasonal low flows. Priority is given to projects regrouping several farmers and must be specifically designed to support WFD targets. Their implementation is widely debated, and further adoption will need to take into account their potentially large visual and environmental impact (i.e. affecting winter flow dynamics) (see Granjou and Garin, 2006).

Rainwater and runoff harvesting in small ponds and reservoirs (with storage capacities of 100–10,000 m<sup>3</sup>) is being promoted in many countries to increase farm resilience to droughts and reduce abstraction pressure. However, their multiplication in catchments can cumulatively lead to major modifications of hydrological regimes (Carluer et al., 2016b). Their impact on the overall water balance should be considered.

The second half of the 20<sup>th</sup> century has also seen a major growth in the use of groundwater by agriculture, in particular in countries of southern Europe such as Spain but also in northern countries such as The Netherlands and the UK (Foster and Custodio, 2019), often contributing to increase water imbalances at catchment level (Llamas and Martínez-Santos, 2005; De Stefano et al., 2015).

There is a growing interest in more coordinated (“conjunctive”) use of surface water and groundwater, where surface water is used in wet years and groundwater in dry years, so as to maximise the availability of water during dry years (i.e. groundwater is used as an underground reservoir). Managed aquifer recharge may be used to maximise benefits from the storage capacities of groundwater bodies and better regulate groundwater–surface water exchanges. Managed aquifer recharge is increasingly used for improving supplies for drinking water purposes, but there is scope to expand use for across Europe (Sprenger et al., 2017) including by combining it with wastewater reuse schemes (Zuurbier et al., 2018). Although studies of conjunctive use have been done at local and regional level (e.g. Pulido-Velazquez et al., 2008; Guyennon et al., 2017), the potential at EU level is yet unknown.

The use of alternative water resources such as desalinated water and treated wastewater, is poorly documented, but limited available evidence suggest it is minor at European level (BIO by Deloitte, 2015). Some countries nevertheless have implemented reuse in a large scale, such as Cyprus which reuse up to 90% of its wastewater.

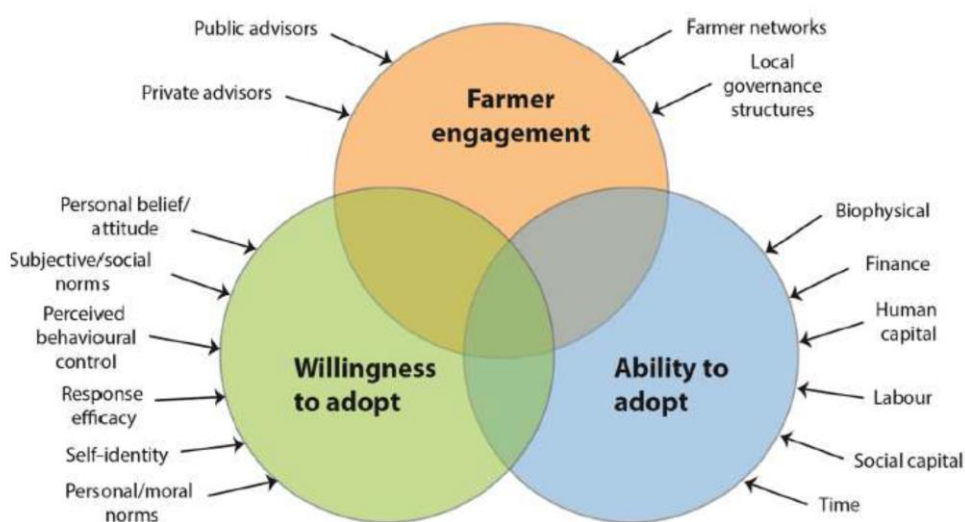
Greater use of non-conventional water face acceptability issues, design and technological challenges, and various financial, environmental and climate risks (Kirhensteine et al., 2016) . Furthermore, wastewater reuse should account for existing uses, including environmental needs, which have to date been dependent on the steady flow of wastewater discharges. Redirecting wastewater discharge towards reuse instead of receiving water bodies might negatively affect ecological conditions during low flow conditions; Hence not all wastewater is available for reuse and careful catchment balances are needed to assess real potential (Drewes et al., 2017).



### 4.2.3 *Influencing uptake of more sustainable water management and farm practices*

The uptake of more sustainable water management and farm practices run against established production models. Radically altering agricultural systems is likely to disrupt established investments, jobs, consumption patterns and behaviours, knowledge and values, inevitably provoking resistance from affected industries, regions or consumers (EEA, 2019g). There are thus strong economic, social and psychological barriers that can lock the agricultural sector existing production modes. Transforming farm practices and moving towards sustainability can be very costly at farm level. It was estimated that meeting WFD requirements relating to abstraction pressures in some agricultural dominated basins of Southern France could reduce up to 50% of gross margin of certain farms (Danel, 2011).

To achieve a transition, a deep understanding of farmers' decision-making is needed. Farmers' decisions are shaped by a complex array of biophysical, economic, technical, social, political and institutional factors (Dwyer et al., 2007; Blackstock et al., 2010; Mills et al., 2017). **Error! Reference source not found.** provides a schematic overview of factors influencing farmers' decision-making commonly reported in the research literature. These system elements, and their evolution, creates both opportunities and barriers to change practices towards more sustainable solutions.



**Figure 4.1 Factors influencing farmers decision-making (Mills et al., 2017)**

Public policies have a key role to exploit these factors and create the right institutional, political, technological, economic and social environment to facilitate the transition towards more sustainable agricultural production models. Decision-makers have a wide range of instruments at their hand to encourage uptake of more sustainable solutions. Given the wide range of factors influencing farmers' decision-making, policy mixes combining different forms of interventions and policy interventions are more likely to be effective (Garforth and Rehman, 2006):

- Adoption can be triggered by raising awareness, building social capital and facilitating collective action (Blackstock et al., 2010). Effective uptake is not solely driven by scientific advice, but by more inclusive processes leading to the co-creation of knowledge with farmers that improve the applicability and relevance of scientific knowledge to the particular local conditions of the farms. In that sense, creating networks between farmers to share experience and spread innovations are



essential tools, which are at the core of agroecological practices (FAO, 2018a; EIP-AGRI, 2020).

- When lack of financial resources, time or labour block adoption of measures, other instruments may be more effective, for example economic instruments, such as prices, taxes and market mechanisms, and regulatory instruments, such as limits and bans to the use of harmful inputs to the water environment, and broader sustainability standards.

Past policy emphasis has been on improving efficient use of resources, although more sustainable farm practices and production models have also been pro-actively adopted by the farming community, and are increasingly supported by the European policy framework. However, to move further towards sustainability, uptake needs to be wider and more profound. Two approaches to scale up can be contrasted:

- An incremental approach would support improved resource efficiency to increase the environmental performance of farms, and broaden approaches adopted in a limited range of farms and production systems to a wider set of farms and environments.
- A more transformative approach would encourage a wider and more systemic change, not only in agricultural production but also in the drivers of agricultural production, i.e. in the societal systems consuming agricultural commodities in the form of food, energy and other bio-products such as fiber for clothing and industrial processes.

The next sections in this Chapter 4 explores how the current EU policy framework has so supported an incremental approach, and how this approach can be strengthened with recent initiatives. A more transformative approach is explored in more depth in Chapter 5 when drivers in consumption systems are presented in more depth.

### 4.3 Implementation of environmental policies

The European Union has adopted several environmental legislations and regulations which requires tackling agricultural pressures on the water environment to achieve their objectives (Chapter 1). Each legislation has its own intervention logic and instruments, which together form a complex but comprehensive policy framework to tackle nutrient and chemical pollution, water abstraction and hydromorphological alterations from agriculture.

The WFD has been a key driver in the definition and implementation of measures tackling agricultural pressures. Under the WFD, RBMPs are the main instrument to support the reaching of good status in all of Europe's surface water and groundwater. RBMPs provide a comprehensive planning approach to identify agricultural pressures and present an integrated set of measures, optimising the use of existing mandatory measures required by other EU legislation, and selecting supplementary measures to meet good status. Recent evaluations of RBMPs show that many measures have been adopted to tackle agricultural pressures from diffuse pollution, water abstraction and hydromorphological modifications (EC, 2019a).

The following sub-chapters focuses on the implementation of existing EU environmental policies, including recent ones under key instruments of the EU Green Deal. The enforcement of environmental policies are reinforced by sectoral policies, in particular the instruments under the Common Agricultural Policies. These are presented in Chapter 4.4.



#### 4.3.1 *Tackling diffuse pollution*

Nutrient diffuse pollution from nitrates and phosphorous is the main reported pressure from agriculture followed by chemical pollution from pesticides; other pollutants include sediments, microbiological/bacteriological and other pollutants such as veterinary products (Chapter 3.1). However, diffuse pollution has been notoriously difficult to address due to the number of actors (farmers) to involve in order to have a noticeable impact on water quality.

##### *Tackling nutrient pollution*

Action on nutrient pollution has a long history in Europe, starting in the 1970s with several major international conventions tackling the issue of air pollution and eutrophication of freshwater and marine waters. Nutrient diffuse pollution is the most extensively covered agricultural pressure in the RBMPs since many water bodies across Europe do not meet nutrient conditions consistent with good status. The main instrument to tackle agricultural nutrient diffuse pollution in the EU is the Nitrates Directive (EU, 1991), although Member States and river basin authorities have also adopted their own national and river basin measures to meet good status.

Under the Nitrates Directive, Member states must establish codes of good agricultural practices, which specify periods when the application of fertilizers and animal manure is prohibited and the conditions for fertiliser application, minimum storage capacity for animal manure, and beneficial crop management practices (rotations, soil winter cover, catch crops). Member States must also monitor water quality, identify waters polluted by nitrates, designate nitrate vulnerable zones (NVZs) and develop action programs which outline compulsory measures in NVZs. In NVZs, the codes of good agricultural practices become compulsory together with additional measures relating to limitations on fertilizer application (mineral and organic) and all nitrogen inputs onto soils, and maximum amount of livestock manure.

There has been a net improvement in the EU towards reduced nitrogen surplus on farmland (Chapter 3.1), which is usually attributed the adoption of the Nitrates Directive. Restrictions on fertiliser application and stricter application standards have contributed significantly to these improvements, together with improved manure application and storage (Webb et al., 2010; van Grinsven et al., 2012). Landscape features such as buffer strips, constructed wetlands and sediment ponds, have also helped reduced the risk of leaching and runoff. Manure surplus management has been used to export excess nitrogen and phosphorous to areas with manure deficits and where they can work as a substitute from mineral fertiliser. Increased use of manure can be supported with adequate definition of nitrogen fertiliser equivalencies (van Grinsven et al., 2012).

More could be done to improve efficient nutrient use. The New Circular Economy Action Plan (EC, 2020b) and the Farm to Fork Strategy (EC, 2020c) call for integrated nutrient management action plan to tackle nutrient pollution at source, in particular in the livestock sector. The Farm-To-Fork Strategy (EC, 2020c) sets an ambitious target of reducing nutrient losses by at least 50%, without deterioration to soil fertility. It calls for better implementation of existing legislation, but also the identification of nutrient load reduction needed, wider application of balanced fertilisation and sustainable nutrient management, and better management of nitrogen and phosphorus throughout their lifecycle.

Full implementation of the ND is certainly needed in the future to support the achievement of WFD objectives (EC, 2019b). Up to 30% of infringements have been observed following site controls, in particular regarding manure storage and fertilisation near rivers. Derogations have been applied to the ND requirements on maximum manure application at farm level (170kg/ha) in six countries (EC, 2018). Furthermore, not all measures have been used fully. For example, to



date, only half Member States apply nutrient balance assessments under the RBMP planning process (EC, 2019a), despite evidence of their effective contribution in optimising nutrient use (Cherry et al., 2012; Wu and Ma, 2015).

NVZs now cover 61% of the EU's agricultural area (EC, 2018). Some MS (i.e. Austria, Belgium, Denmark, Germany, Ireland, Luxemburg, the Netherlands, and Slovenia) have opted to designate their whole territories as vulnerable zones, thereby opting for the same approach to all their farmers. Other Member States have opted for designating particular areas, which may, in some cases, not include sufficiently all the area draining into waters where they cause pollution to ensure effective action programmes (EC, 2018). With some regions in Europe reporting 1% uptake of good agricultural practices amongst farmers outside NVZs (EC, 2018), environmental gains may be possible if their uptake were generalised.

Precision farming has a major role in balanced nutrient management, as well as uptake of innovative solutions, such as improved feeding through more balanced nitrogen and phosphorus levels in livestock diet to decrease total phosphorus emission in manure (Klootwijk et al., 2016b) and slurry injection to improve the assimilation of nutrients in soils, as required in The Netherlands.

Despite improvements, fertilization rates in Europe remain high in global perspective (Erisman et al., 2011) and fertiliser use has remained generally stable at European level in recent years (see Chapter 2). Additional policy instruments may be designed into policy mixes that combine incentives together with regulatory and voluntary schemes, as implemented in Baden-Württemberg (Germany) (Möller-Gulland et al., 2015).

Stricter restrictions on the use of fertilisers and manure may be required to achieve environmental objectives, for instance as a total cap on fertiliser and manure use, or livestock density, on hydrologically relevant scales. However, to be effective, the cap should be assessed against transparent and measurable nutrient load reduction targets (Box 4.2). As restrictions become more costly and may affect yield, more targeted approaches may be needed to reduce total cost of reaching nutrient reduction goals.

#### **Box 4.2** Danish action on nutrient pollution

Around 60% of the territory of Denmark is arable land and permanent crops (Figure 2.1). A significant reduction of nitrogen and phosphorus input to surface waters and groundwater is crucial to reach objectives of the WFD. Based on 2<sup>nd</sup> RBMP, 28% of all surface waters and 78% of all groundwater bodies reach the WFD good status objectives. Status of coastal waters is worse with only 2 % of water bodies in good ecological status. High nitrogen use in agriculture is a major cause of pollution in Danish coastal waters.

Denmark has been addressing nutrient pollution with national policies starting in 1987 with the first Action Plan on the Aquatic Environment aims with a 50% reduction goal for nitrogen discharges from point sources and leaching from diffuse sources and an 80% reduction of phosphorus discharges from point sources. The Plans for Sustainable Agriculture and the National Action Plan II and III for the Aquatic Environment was adopted according to obligations of Nitrates Directive. The third update of the Action Plan for the Aquatic Environment for the period 2005 to 2015 aims at halving phosphorus surplus in soils and reduce nitrogen leaching significantly.

The Green Growth Agreement, adopted in 2009, sets annual nitrogen load reduction targets in coastal waters of 19 000 tonnes. Those targets were also adopted in the 1<sup>st</sup> RBMP 2014 (6 600 t N), the Food and Agriculture Agreement 2016 (8,000 t N), and the 2<sup>nd</sup> RBMP (2016). The



upcoming 3<sup>rd</sup> RBMP plan a reduction of 6,200 t N in coastal waters. Those targets have also progressively provided the Danish contribution to the Baltic Sea Action Plan.

In the future, Denmark plans to develop a Targeted Regulation to keep pushing forward the reduction of nutrient losses to aquatic ecosystems in accordance with the WFD objectives. This Regulation specifies the effort and differentiates the needed measures to 3 000 Danish areas taking different soil types vulnerability to water erosion or potentially nitrate losses into account. For each area, different requirements will be set on farmers based on reduction needs. Such targeted approach to regulation could have significant economic consequences for farmers situated in the most critical areas. Compensation for farmers may be implemented using compensatory measures under the future Danish Rural Development Program.

Source : Maar et al., 2016; Carter and Cherrier, 2013; Christensen, 2017; Kronvang et al., 2017; Miljø- og Fødevareministeriet, 2019

### *Tackling pollution from pesticides, metals, and veterinary medicines*

Contamination caused by chemical pollutants from agricultural activities is very varied and a major concern in many European countries (Chapter 3.1). The WFD requires the adoption of measures to control the discharges, emissions and losses of priority and priority hazardous substances into the aquatic environment. Emissions of priority substances should be reduced while emissions priority substances should be ceased or phased out. The list of priority and hazardous substances includes several pesticides and heavy metals, and pollution from veterinary products are an emerging concern. As pesticides and heavy metals are persistent in the environment and can bio-accumulate, it is essential that management is primarily about reducing or avoiding use altogether.

Regarding the management heavy metals from agriculture, threshold limits for key substances in sludge applied to agricultural land have been set by the Sewage Sludge Directive. Monitoring is required on the sludge and the receiving soil to take into account cumulative concentrations. The Directive bans the spreading of sewage sludge when the concentration of certain substances in the soil exceeds these values. In addition, the directive sets time restrictions for sludge application in order to provide protection against potential health risks from residual pathogens.

Reduction in the total amount of metals in sludge has been observed for regulated metals, with the largest decrease for cadmium, chrome and mercury (Fijalkowski et al., 2017). Member States have added other substances for control than those contained in the Directive, and implemented stricter limit values. However, improvements is warranted to achieve better environmental outcomes. For instance, total content may not be a reliable indicator to assess the availability and toxicity for living organisms (Fijalkowski et al., 2017). Furthermore, a wider spectrum may need to be monitored as sewage sludge contains organic and inorganic contaminants not yet regulated by law, such as many pharmaceuticals, personal care products, nanoparticles and pathogens (Fijalkowski et al., 2017). These issues are of relevance also for the reuse of wastewater in irrigated areas (Chapter 4.3.5).

Since 1991, EU action against pesticide pollution has gradually strengthened over the years, first by establishing greater control on the authorisation of active substances on the EU market, then by establishing provisions for the safe collection and disposal of waste, and more recently by targeting consumption levels. The use of pesticides is regulated through the Sustainable Use of Pesticide (SUP) Directive (EU, 2009a), which sets out a framework to achieve sustainable use. It promotes integrated pest management (IPM) (Box 4.3), and foresees mandatory inspection of pesticide application equipment, training of users, advisors and distributors of pesticides, prohibition of aerial spraying, limitation of pesticide use in sensitive areas, and mitigation of risks



through improved spray technology and application of buffer zones, and proper management and cleaning of equipment after spraying.

At Member States level, national action plan must be developed to show how risks and impacts of pesticide use will be reduced. To date, measures have focused to date on establishing systems for the training and certification of operators, a range of measures for the safe handling and storage of pesticides, and technological improvements for the efficient spraying of pesticides (EC, 2020f). Initiatives exist on increasing awareness of IPM amongst farmers, such as the Lithuanian labelling system on pesticide, as well as its monitoring and reporting by farmers (ECA, 2020).

Progress in reducing pesticides use has nevertheless been very limited (Chapter 2). The Farm to Fork Strategy (EC, 2020c) and Biodiversity Strategy (2020) (EC, 2020d) have put renewed attention on pesticides use, and aim to reduce overall use and risk of chemical pesticides at European level by 50% and the use of more hazardous pesticides by 2030. In addition, the Farm to Fork Strategy has set a goal to reduce overall EU sales of antimicrobials for farmed animals and in aquaculture by 50% by 2030. To achieve these ambitious objectives, significant changes in farm practices need to occur.

For example, implementation of IPM has been slow, with little evidence of widespread application by farmers (Lefebvre et al., 2015). Practical and measurable guidelines and criteria at farm level should be developed to improve monitoring of progress and increase awareness (ECA, 2020). Although farmers are required to apply IPM, they are not always required to keep records of how they applied it and there are weak penalties for non-compliance. Evidence also suggests that systemic change is required not only at farm level, but also across the actors of the whole value chain – including pesticide retailers, farm advisory bodies, and the food industry - to move away from existing standards and requirements locking farmers into current practices. This lack of broader value chain support was a major factor explaining the lack of progress in ambitious national policies, such as the First Ecophyto Plan in France (Guichard et al., 2017).

Full implementation of IPM principles of the SUD is necessary, but also other measures. The definition of non-chemical and low-risk plant protection product could be clarified, as is the recording and reporting in the use plant protection product at national and European level to better measure progress (ECA, 2020). Given the continuous emergence of new chemicals, methods of detections must be strengthened as are authorisation procedures supported by scientific evidence. Cumulative risks must be considered. Adoption of precision farming and further innovations in pesticide application techniques can also improve fertiliser use efficiency (Dean et al., 2011). More ambitious measures are also warranted, such as the use of quantitative reduction targets in pesticide use (Skevas et al., 2013) and the wider use of ambitious pesticides tax schemes (Pedersen et al., 2015; Böcker and Finger, 2016).

#### **Box 4.3** Integrated Pest Management (IPM)

IPM encourages first pest prevention through adequate crop and livestock management practices. In cropping systems, it promotes crop diversification through spatial diversity (e.g. intercropping) and temporal diversity (e.g. longer crop rotations) to break pest and disease cycles. Improved tillage practices and avoidance of soil compaction can reduce erosion and support healthy soils, increasing chemical breakdown before leaching and runoff into surface water and groundwater bodies. Preserving and supporting important beneficial organisms fighting pests and diseases, but not damaging crops or livestock, are encouraged, as is the development of more resistant seed and crop varieties and animal breeds. In livestock systems, appropriate hygiene and housing can reduce risks, as well as lower livestock



densities. Crop and livestock management should be complemented by an efficient monitoring of pest and disease development. Biological methods together with physical handling should first be used, and, when necessary, suitable chemical methods may be adopted to protect crops and livestock.

Sources: Meissle et al., 2009; Lamichhane et al., 2015; FAO, 2018a

#### 4.3.2 *Tackling pressures from agricultural water use*

Agriculture is a major driver of abstraction pressure in EU's water bodies (Chapter 3.2). The EU's response to abstraction pressures has been mostly cross-sectoral, formalised through the EU Action on Water Scarcity and Droughts 2007 and consolidated through the Blueprint for Safeguarding Europe's Waters 2012. At river basin level, the implementation of RBMP has led to the uptake of a wide variety of management measures on agricultural irrigation (EC, 2019a).

##### *Prior-authorisation and abstraction control*

Under the WFD, significant abstraction points in surface water and groundwater should be registered and subject to prior-authorisation through e.g. a permit system. Member States should inspect and enforce penalties on non-authorised users who does not comply with the specification of the permit requirements.

Recent evaluations indicate that member states have adopted various mechanisms to better control agricultural abstraction. Authorisation procedures are generally in place in all Member States and the majority of countries and RBDs have also conducted assessments of water balances (Buchanan et al., 2019). Water balances provide an overview of the volume and flow of water in the various components of the hydrological cycle within a specified hydrological unit (e.g. a river catchment or river basin), occurring both naturally and as a result of the human induced water abstractions and returns. Water balances are seen as essential components of sound quantitative management of water resources under the WFD (EC, 2015).

Some countries have gone further by limiting water abstraction and issuing volumetric allocations that take into account the renewable freshwater resources and environmental flow requirements. France for instance has adopted volumetric management where capped agricultural allocations are managed by agricultural user groups, while some river basin authorities and user groups in Spain have established sophisticated controls on capped abstraction (Box 4.4).

Despite progress, there remains significant implementation issues regarding abstraction control. Illegal abstraction in the form of unauthorised, unregistered, unmeasured or unmetered abstraction, also continues to be a major challenge (Schmidt et al., 2020). Half of the wells in European Mediterranean countries may be unregistered or illegal (EASAC, 2010). Not all abstraction points are reported, and volumes are not systematically metered. The multitude of abstraction points makes it particularly difficult for authorities to regulate water use. However, river basin authorities are developing sophisticated strategies to improve the recording of agricultural abstraction and its monitoring (Schmidt et al., 2020).

Most Member States apply exemptions to permitting and the registration of small abstractions, and the analysis of abstraction may not consider the cumulative impact of abstraction points. This is a major concern for groundwater but also surface water bodies where farmers abstract water through individual pumping systems. The lack of consideration of, and control over, small abstraction points in some Member States lead to an underestimation of abstraction levels from agriculture.



Finally, further work is needed to harmonise the use of water balances across river basins. To realise their full potential, water balances must give careful consideration to system interconnectivity between surface water and groundwater bodies, the relationship between water flow, quality and ecological status, the consideration of climate change and assumptions regarding consumptive use and return flows. Further guidance is planned in the recent Biodiversity Strategy 2030 (EC, 2020d) regarding how to better link the review of abstraction permits with the aim of restoring ecological flows under the WFD.

#### **Box 4.4 Volumetric control on abstraction of agricultural irrigation**

Limits on total agricultural abstraction have been adopted in some river basins in Europe. In France, the Water Law in 2006 requires abstraction caps in priority catchments and aquifers, where resources are deemed overallocated. Once the cap is set by authorities, together with users, the portion allocated to agriculture is managed by an agricultural collective management organisations called “Organismes Uniques de Gestion Collective” (OUGC). The OUGC is conceived as administrative (relay) institution to improve local knowledge of agricultural abstraction, pool individual water demands annually, define allocations between farmers and report use after the irrigation season. Policing and compliance remain in the control of public administrations. This comanagement between authorities and agricultural users has contributed to improve knowledge of agricultural abstraction in basins and aquifers and to reinforce local control on agricultural abstraction.

In Spain, user associations have also been created to manage overexploited aquifers. The management of some aquifers, such as the Mancha Oriental, present some elaborate forms of monitoring and controls on abstraction based on Earth Observation information. Farmers are required to prepare an irrigation plan specifying which crops will be irrigated and where. Based on this, the user association performs continuous earth observation to detect potential cases of over-abstraction and target field inspections. This is assisted with calibrated flowmeters on wells. This has significantly improved controls and the water table level has been stabilized.

While the French and Spanish case present advanced experiences on controlling abstraction, there are many challenges in implementation. Ideally, water permits should be reviewed to reduce the overallocation. However, historical water use rights and entitlements pre-dating the WFD may persist, and authorities usually face significant legal and political constraints in modifying them. In France for example, the definition of abstraction caps imply that agricultural extractions have to be reduced by 10 to 20% compared to historical use in most priority catchments and by over 50% in some cases. Reductions are to be achieved with no financial compensation. Ambitious reforms are needed to overcome these barriers and engage in a full and wide ranging review of existing permits.

Sources: Playán et al., 2018; Ortega et al., 2019; Rouillard and Rinaudo, 2020; Arnaud, 2020; Schmidt et al., 2020

#### ***Restrictions during droughts***

River basin authorities have improved the use of drought management plans, which dictate measures when precipitation is significantly below normal recorded levels. To ensure sufficient water flows reaches downstream ecosystems and water users, river basin authorities have set target minimum flows across river basins and established emergency controls where water



users, including irrigated agriculture, undergo increasing restrictions on their water use as these target river flows and aquifer levels reach minimum thresholds.

In Europe, authorities typically consider agriculture as a non-priority use compared to drinking water services. Hence, agriculture often bear most of the restrictions on water abstraction during drought conditions and most of the reduction in allocations to meet sustainable abstraction limits. The agricultural sector faces major challenges to minimise economic losses, especially as Europe is facing more frequent and intense droughts in the future.

Drought forecasting and preparedness should alleviate the problem, while sophisticated mechanisms to optimise water allocations in agriculture during droughts, while meeting environmental flows, are being developed in several countries (Kampragou et al., 2011; Rey et al., 2017). This includes for example real-time monitoring of river flows and abstraction, as well as intra-annual water reallocation between users. Some countries such as Spain use water market mechanisms to reallocate water (Garrido et al., 2012).

#### *Water use efficiency and crop productivity*

European policies aims to promote water use efficiency in agriculture, an approach reinforced by the EU Green Deal (EC, 2019c) goal towards a resource efficient economy. At global level, Europe is usually considered to be more efficient in irrigation water use (e.g. Jägermeyr et al., 2015). However, studies have suggested that up to 43% of agricultural water use could be saved in Europe (Dworak et al., 2007).

Implementing incentive pricing for the use of water and increasing the cost recovery of abstracting, storing and delivering irrigation water is part of the WFD (Box 4.5)). It is expected that cost recovery and incentive pricing can support greater efficiency in water use, and encourage a shift to crops, irrigation technologies and practices that reduce wastage and ensure an efficient use of water. Cost recovery and volumetric pricing in irrigated agriculture have been more widely adopted in recent years, although many Member State do not yet implement it fully for several social, economic and political reasons (Giannakis et al., 2016; Expósito, 2018; EC, 2019a). It is important to note that incentive pricing does not necessarily result in water savings. Case studies have shown that low water prices limit its impact, but also other factors, such as fertiliser or energy costs, have a stronger impact on water use (Bogaert et al., 2012).

#### **Box 4.5 Cost recovery and incentive pricing on agriculture under the WFD**

Cost recovery of water services is a general principles in the Directive, which Member States should apply except where it does not compromise the purposes and achievement of the objectives of the WFD (ECJ, 2014). Cost recovery and incentive pricing principles under the WFD on agriculture can be outlined in the following way:

Element 1 – there is an incentive pricing policy to use water resources efficiently.

Element 2 – there is adequate contribution of the agriculture sector (including self-abstraction for irrigation) to the recovery of the costs of water services, including environmental and resource costs reflected in pricing policy.

- For MS/Regions to demonstrate full compliance with Article 9 of the WFD, the following conditions would be met:
- All abstractions from surface and ground waters (and reservoirs) for agricultural use are subject to a permit and are regulated by water meters.
- There is an inspection system and fines/penalties for a farmer who does not comply with the volume defined in the permit requirements.
- All abstractions from surface and ground waters (and reservoirs) by farmers are subject to a fee (i.e. price).



- The price paid for water is based on the volume of water abstracted by individual agricultural uses. The volume of water (paid for) is calculated by an individual farm level meter.
- There is a clear government commitment (i.e. regulation) to apply volumetric pricing policy for all agricultural users. The pricing policy provides incentives for the agriculture sector to shift to crops, irrigation technologies and practices that ensure efficient use of water or, in water-scarce areas, to less-water consuming crops.
- The price paid for water internalises environmental and resource costs, i.e. the water price charge to farmers goes beyond costs linked to infrastructure such as maintenance, energy, distribution, etc.

Source: Berglund et al., 2017

Member States have made significant investments into efficiency programs, including improved irrigation scheduling and advice provision, reduction in water loss conveyance, and water saving irrigation technologies (Giannakis et al., 2016). Drip and sprinkler irrigation, which have the highest water efficiency (respectively 85-95% and 70-85%), generally prevail in Europe, while many gravity-fed and surface irrigation systems of lower efficiency (40-60%) remain across Europe, in particular amongst small farm holders in the Mediterranean where surface irrigation has traditionally been used. Moving to more efficient irrigation, for instance by improving the lining of canals or switching to pressured and drip irrigation systems, could further save water.

The performance in irrigation water use can be estimated through the water intensity of crop production, which relates the amount of water used to produce a crop to its economic value. The water intensity of crop production in Europe has reduced by 12% between 2005 and 2016 (EEA, 2020b). The strongest reduction occurred in Eastern Europe (nearly 32%) due to increases in the gross added value generated by crops and a reduction in abstraction per ha. Southern Europe countries also reduced its water intensity (about 10%), although some countries such as Cyprus, Greece, Italy and Malta experienced an increase due to an increase of abstraction per ha and a decline in added value linked to lower crop yields, possibly as a result of climate change.

The idea that moving to more efficient use in irrigation systems and increasing water intensity (productivity) is always beneficial in environmental, social and economic terms warrants some words of caution (Zoebl, 2006; Berbel et al., 2018). More efficient irrigation infrastructures require large investments and have higher operational and running costs, placing additional burden on farm finances (Dumont et al., 2013; Masseroni et al., 2017). Furthermore, return flows resulting from highly inefficient irrigation systems can contribute to base flows beneficial to downstream uses and sensitive ecosystems, which may have developed over centuries and have high cultural values. Higher efficiency lead to reduced percolation losses, thereby impacting return flows.

Investments in water efficiency programs should therefore be accompanied by a careful consideration of water balances at farm, basin and aquifer level, including consideration of surface-groundwater exchanges and dynamics and impact on groundwater-dependent ecosystems (EC, 2015; Expósito and Berbel, 2017). Attention needs to be given to potential rebound effects (see Textbox 4.1) and ensure that the saved water is reallocated to environmental needs.

#### *Reducing demand and enhancing rainfed agriculture*

As river basins adopt more water efficient irrigation, further gains will be limited and technological improvements may reach their capacity to deliver new value and reduce water use. Findings suggest that productivity gains may have reached a ceiling in some southern European river basins as various innovations, such as new crops, deficit irrigation, and water-



saving and conservation technologies, have reached their full capacity (Expósito and Berbel, 2017). Hence, other measures may be needed to match total water demand with water availability.

As river basin progress towards total resource limitations, the full impact of agriculture on the basins' hydrology should be accounted for, including both its use of blue and green water. This would require managing water in rainfed and irrigated systems in an integrated way, looking at ways to maximize water savings by managing evapotranspiration and crop water demand, enhancing soil water retention capacity, and increasing the productivity of rainfed agriculture (Rockström et al., 2010; Molden et al., 2007b). This would also contribute to increase farms' resilience to water scarcity and droughts.

Soil preservation and crop diversification practices promoted in conservation farming and agroecology contribute to these objectives, with evidence that farms practicing organic farming have shown greater resiliency to droughts by maintaining higher yields than non-organic farms (e.g. Milestad and Darnhofer, 2003; Altieri et al., 2015). Healthy, carbon-rich soils have higher water retention capacities (Adhikari and Hartemink, 2016). Various techniques can be used to increase the capacity to reduce crop water demand, including the use of modified crop calendars to benefit from higher rainfall and soil moisture content during wetter season, modified crop rotation and rotational fallowing, developing more water resistant varieties and adopting more water-stress resistant crops (Debaeke and Aboudrare, 2004; EIP-AGRI, 2016, 2020). Deficit irrigation has large potential in permanent cropping systems to optimize and reduce water use during drought conditions (Feres and Soriano, 2006). Combining crops or pastures with trees in agroforestry systems can also buffer exposure to climate change extreme such as storm damage, heatwaves and droughts (OECD, 2014).

It is also important to acknowledge that a total switch to rainfed agriculture can reduce costs to farmers, but it also increases exposure to lower yields and crop failure during droughts. A coherent strategy on supplemental irrigation or adequate crop insurance for rainfed agriculture may be needed to mitigate risk.

#### **4.3.3 *Tackling hydromorphological pressures from agriculture***

Agriculture leads to a variety of hydromorphological pressures (Chapter 3.3). Under the WFD, authorities have established controls to avoid further deterioration typically by requiring prior-authorisation (licensing) of land drainage and for building infrastructure such as water storage for irrigation purposes. Fencing of watercourses has also been implemented in livestock areas to prevent morphological deterioration. Restoration action is also required where pressures impact the good status of surface water bodies. For agriculture, much restoration focus on drainage impacts (Vartia et al., 2018).

A variety of other policy initiatives support the restoration of water bodies from agricultural pressures, notably the EU note on Better Environmental Options for Flood risk management (EC, 2011b), the Green Infrastructure Strategy (EC, 2013) and the concept of Natural Water Retention Measures ( Box 4.6). More recently, the Biodiversity Strategy 2030 established a goal to restore the longitudinal connectivity of water bodies by 25000 km, which may affect various irrigation storage infrastructure.

European-wide overview of measures tackling hydromorphological pressures from agriculture is complicated due to lack of data. Evidence exists of countries implementing river restoration measures to remeander river courses, enhance riparian habitat, remove embankments, weirs and barriers (e.g. reservoirs) and reconnect rivers and floodplains. Other measures target



agricultural land to promote a landscape-wide restoration of hydrological processes and reduce sediment flow, for example via changes in crop and soil management to reduce erosion.

By removing storage capacity for irrigation water, flood protection and restoring groundwater tables, hydromorphological pressures can impact the productivity of agricultural land. To further enable restoration programs, a comprehensive framework may be needed, such as the planned EU Nature Restoration Plan.

#### **Box 4.6 Natural water retention measures and agriculture**

Natural Water Retention Measures (NWRM) are multi-functional measures that aim to protect and manage water resources using natural means and processes, for example, by restoring ecosystems and changing land use. Their main focus is to enhance and preserve the water retention capacity of aquifers, soil and ecosystems with a view to improving their status. The European platform on NWRM (<http://nwrn.eu/>) offers an overview of these solutions, with technical specifications and case studies on their application across Europe.

A wide diversity of measures are classified as NWRM. In areas affected by agriculture, such measures may include on-farm measures (e.g. buffer strips, soil conservation practices like crop rotation, intercropping, conservation tillage) as well as landscape-wide measures (e.g. floodplain and wetland restoration).

NWRM have the potential to provide multiple benefits, including flood risk reduction, water quality improvement, groundwater recharge and habitat improvement. For example, riparian buffer zones in agricultural areas primarily aim at reducing nutrient losses and/or increase biodiversity, but they may also reduce peak flooding. However, as the area covered by NWRM is generally small with respect to managed (agricultural or forest) land area, their individual impact on downstream flooding is usually relatively minor.

Overall, NWRM are still far from being applied in all cases in which they would be an option or the best option and there is a need for a change of thinking to ensure NWRM are duly considered in planning processes. Enhanced knowledge is required for supporting the optimisation of NWRM and their combination with other measures, for quantifying their impacts at large scale, and for estimating all their benefits.

The effectiveness of NWRM for different objectives including flood risk reduction and the reduction of hydromorphological pressures from agricultural use could be enhanced, if they were implemented at larger scale. If many farms adopt these type of measures such as riparian buffers or soil conservation practices at the same time in the same catchment, the effect could be larger compared to single applications on few farms.

Source: EC, 2014; Saukkonen, 2016; Collentine and Futter, 2018

#### **4.3.4 Other water, biodiversity, marine and climate adaptation policies**

Other environmental policies can contribute to tackling agricultural pressures on the water environment. For example, the Drinking Water Directive (EU, 1998) establishes quality standards at EU level on several substances emitted by agriculture (e.g. nitrates) and requires establishing drinking water protected areas, in which human activities are subject to more stringent controls. The protection of drinking water protected areas has been reinforced through the WFD, and it has since driven restorative action by authorities on agricultural land. For example, the uptake of organic farming reduction on drinking water areas in the vicinity of Leipzig has led to a reduction of nitrate concentration from 40mg/L to 20mg/L in groundwater (Grüne Liga, 2007).



Drinking water utilities and bottle water companies increasingly value the cost-effectiveness of tackling agricultural drivers at the source by changing farming operations to reduce the use of nutrients and pesticides loads through more efficient use of inputs or changing practices towards more agroecological practices. However, they have faced legal and operational constraints and most action on diffuse pollution is focused on mitigation and remediation actions such as displacing drinking water wells (EC, 2016). The Directive is currently undergoing revisions to allow further prevention and mitigation measures to protect drinking water sources, and will extend a range of emerging pollutants, including from agriculture such as additional endocrine disruptors and pesticides.

The Nature Directives do not state any direct relevance to agriculture and water; however, the conservation measures which must be put into place for terrestrial ecosystems may involve actions that concern this area. For example, reduced input of chemical fertilisers and plant protection products as well as reduced habitat pollution or fragmentation contribute positively to water quality, reducing erosion, contamination and compaction. In addition, the Birds Directive promotes the protection of wetlands, which have a positive impact on the water household.

The recent Biodiversity Strategy illustrates well these important linkages, with ambitious targets relating to the reduction of the emission of chemical pesticide by 50% by 2030, the expansion of organic farming to 25% of agricultural utilised land, the restoration of the longitudinal connectivity of water bodies by 25000 km and the better control of water abstraction affecting environmental flows.

The Marine Strategy Framework Directive promotes the protection and restoration of environmental status in marine waters. Some of the pressures on the marine environment originate from agricultural activities, in particular nutrient pollution and eutrophication. The coordination of marine and water policies can result in more effective responses.

The EU Adaptation strategy on adaptation to climate change (COM/2013/0216 final) aims at making Europe more climate-resilient. Taking a coherent approach by complementing the activities of Member States, it supports action by promoting greater coordination and information-sharing, and by ensuring that adaptation considerations are addressed in all relevant EU policies and funding programmes. The new adaptation strategy (to be published 2021) will also have a focus on the water and agriculture nexus ensuring that both can withstand the changing climate as this is critical reaching many objectives, including preserving ecosystem services.

#### **4.4 Coherence between EU water and agricultural policies**

The transition to more sustainable forms of agricultural production to reduce pressures on the water environment require close integration of the implementation of environmental policies with sectoral policies driving agricultural activities and rural development. The Common Agricultural Policy is the main policy that influences the development of the agriculture sector in the EU. It influences how individual farmers choose to manage their land, crops and livestock. In its preamble paragraph, the WFD already highlighted the importance of close integration with the CAP, and RBMPs heavily rely on funding from rural development policies to implement measures on agricultural land (Buchanan et al., 2019).

The current CAP (2014-2020) aims to ensure a stable supply of affordable food, to enable farmers to make a reasonable living and to address climate change and sustainable management of natural resources. The CAP consists in several regulations which are organised around two “pillars”:



- The “first pillar”, financed via the European Agricultural Guarantee Fund (EAGF), supports agricultural income by delivering yearly direct payments worth 72% of the CAP total budget to 6.7 million farmers (out of 10.5 million), and by intervening on agricultural commodity markets, accounting for 5% of the total budget.
- The “second pillar”, financed under the European Agricultural Fund for Rural Development (EAFRD), aims to support more broadly the competitiveness, social cohesion and environmental performance of agriculture and the rural economy. It covers the remaining 23% of the CAP budget.

According to the legal proposals presented by the European Commission, the next Common Agricultural Policy (CAP) will continue to be financed through these two funds, but a new delivery model based on greater subsidiarity is proposed (EU, 2018b)

Over the time of existence of the CAP and other sectoral policies, considerable progress has been made to streamline environmental objectives. Yet, there is a need for much more ambitious and far-reaching integration given the slow progress towards good status and continued pressure from agriculture on the water environment (ECA, 2014; EEA, 2018d; EC, 2019a).

#### 4.4.1 *Avoiding policy incentives leading to pressures on water*

The CAP is one of the oldest policies, launched in 1962, and a core building block of the European Union. Some of its initial goals were to stabilize agricultural markets, guarantee minimum commodity prices to farmers, and support investment in the modernization of agriculture, with the overall objective to increase food production.

Thanks to this favorable policy framework, European agricultural output increased tremendously, increasing food security in Europe and vastly expanding exports on international markets (Chapter 2). However, at the same time, the use of inputs such as fertilisers, pesticides and irrigation water has increased and agricultural pressures on the European water environment have become more intense (Chapter 3).

In the last 30 years, successive reforms of the CAP have changed significantly the intervention logic of the CAP and the resulting incentive structure on farmers. Under Pillar I, the budget for market interventions which initially determined the market price have mostly transitioned to providing a market safety net. Some market mechanisms still exist in Pillar I under the Common Market Organisation, for example in the form of sector specific aid schemes to support the competitiveness and modernisation of agricultural holdings. This instrument is often used to support investments (e.g. in irrigation) in sectors such as fruit and vegetables, apiculture, wine, hops, cotton and olives.

Most of the Pillar I CAP budget has now been re-oriented towards direct payments to farmers in the form of income support. Direct payments consisted in the 2014-2020 programming period of several schemes, the main one being a basic income support scheme. Others direct payment schemes have more specific objectives, such as supporting young farmers, smaller farms, and specific sectors facing economic difficulties. The “greening” direct payment specifically aims at encouraging the uptake of some sustainable farming practices (Section 4.4.2).

The influence of the current CAP Pillar I on production and use of inputs (e.g. fertilisers, pesticides, irrigation water), and the resulting impact on the water environment, is subject to debate:

- On the one hand, direct payments can represent a substantial share of income of farming systems with a lower impact on water, for example diversified farmers in grass-fed livestock production or extensive farms in areas of natural constraints. This may



maintain their economic viability and prevent their conversion to more specialist arable farming systems.

- On the other hand, direct payments may benefit historical beneficiaries with intensive forms of production, and sector-specific support (under the remaining coupled direct payments or under the market intervention instrument) may encourage further intensification. Some Member States have nevertheless set additional conditions on payments to benefiting farms, such as maximum livestock density and water saving targets (Devot et al., 2020).

It is important to note that the impact of direct payments and sectoral market intervention on farming practices and pressures on the water environment is dependent on many factors, varying with the implementation choice of Member States, characteristics and location of the farm, market conditions, and choices by farmers themselves.

The share of the CAP support in the overall farm income also has an influence. Where payments represent a smaller share of a farmers' income (e.g. fruits, wine, vegetable sectors), the CAP will have less relevance on farmers' choices, and market forces will likely be the predominant factor in the evolution of the farm operations. To prevent intensification in such cases, a more global response is needed, for example via interventions on the broader consumption system to induce the right signal on the evolution of agricultural practices (see Chapter 5).

#### **4.4.2 *Supporting the transition to sustainable farming***

The CAP reforms have resulted in establishing a complex “green” architecture composed of various instruments for promoting environmental and climate friendly farming practices. They can be separated between:

- Instruments mainstreaming environmental standards, i.e. “cross-compliance” in the current programming period and “conditionalities” in the new CAP
- Instruments incentivizing the uptake of more sustainable farming practices, i.e. “greening” measures in the current programming (to be included as environmental standards in the conditionalities in the upcoming period) and “eco-schemes” in the new CAP
- Instruments providing financial assistance to the transition towards sustainable farming, i.e. rural development payments.

##### ***Linking payments to environmental standards***

The 2003 CAP reform established a series of “cross-compliance” rules on environmental protection, food safety, animal and plant health and animal welfare, which farmers must comply with across Europe. Statutory Management Requirements (SMR) apply to all European farmers, and relate to existing environmental legislation. Good Agricultural and Environmental Conditions (GAEC) are additional requirements attached to most direct and rural development payments, and therefore only apply to farmers involved in these CAP support schemes.

In the CAP period 2014-2020, two SMRs (i.e. SMRs 1 and 10) integrated the requirements of the Nitrates Directive and the Sustainable Use of Pesticide Directive, as well as several GAECs are also relevant to water targets, directly and indirectly, including those requiring the establishment of buffer strips along watercourses, groundwater protection measures, soil and land management practices to limit erosion and maintain soil organic matter, and retention of landscape features such as hedgerows. One GAEC required compliance with authorization procedures for abstraction for irrigation purposes.



It is generally acknowledged that cross-compliance offered large potential for tackling pressures on the water environment because they reinforce the widespread enforcement of minimum environmental standards in agriculture. However, evaluations of cross-compliance has regularly highlighted some pertaining weaknesses, which can hinder their environmental effectiveness (ECA, 2009, 2016; Devot et al., 2020).

One common reported issue relates to the generic nature of crops-compliance requirements and their lack of spatial targeting. Under the current system, CAP management authorities set out standards following an approach that can be applied across a region or a country uniformly, so as to minimise administrative burden in compliance-checking. Two notable exceptions include the SMR related to the Nitrates Directive, which accounts for nitrate vulnerable zones, and the GAEC on land management to limit erosion, which integrates the need to account for site-specific conditions. Both support a reduction in nutrient pollution pressures.

There are issues relating to varying level of ambition. For instance:

- The specification of GAEC on buffer strips vary widely across Europe, including minimum width, obligations and restrictions regarding the use of fertilizer and pesticide input, and the type of vegetation cover that can constitute a buffer strip. The most ambitious buffer strip requirements more closely follow scientific recommendations regarding adequate consideration of factors, such as slope of the upstream land, vegetative cover type and maintenance operations, to enhance their effectiveness in tackling nutrient and pesticide pollution (Hickey and Doran, 2004).
- Cross-compliance relating to the use of pesticides was so far been limited to respecting procedures regarding the buying of products, their handling and application (ECA, 2020). Reducing pesticide pressure will require going beyond and implementing an integrated approach to managing pest and diseases, that considers alternative methods and reducing the application rate and frequency, as set out under the Directive on the Sustainable Use of Pesticides.
- Abstraction pressures were tackled by GAEC 2, which requires that the farmer comply with authorisation procedures. Considering the large number of unreported abstraction points, this GAEC has large potential to improve monitoring of water use. A requirement to install a water meter and report water use could improve further the GAEC. Potential additional measures could include the uptake of water saving measures and efficient irrigation systems.

Finally, cross-compliance requirements did not apply to sectoral market interventions and not all direct payments. This exempted certain polluting sectors such as cotton production, wine and vegetables, from meeting these standards when receiving these payments. In the current proposals for the CAP post-2021, some of these payments will remain under different environmental requirements as direct and rural development payments.

The new CAP green architecture proposes to integrate cross-compliance requirements and greening measures (see below) into a set of “conditionalities” on all Pillar I payments. In addition to integrating pre-existing cross-compliance and greening requirements (leaving some flexibility to member states on setting exact levels of ambition), new proposed standards include controls on diffuse phosphate pollution, new Farm Sustainability Tool for Nutrients, and the protection of wetland and peatland would contribute to tackle pressures from agriculture on water.

No conditionality requirement has yet been proposed regarding the mitigation of the impact of hydromorphological changes from drainage schemes and irrigation infrastructure, or measures tackling emerging chemical pollution such as pharmaceutical and cleaning products used in livestock rearing.



### *Incentivising sustainable farm practices*

Under the CAP 2014-2020, farmers could receive a “green payment” for implementing three types of measures: (i) crop diversification, (ii) maintenance of permanent grassland and (iii) Ecological Focus Areas (EFA). Member States and farmers had significant leeway in implementing greening measures.

Experience indicates that farmers preferably implemented “productive” EFAs, including nitrogen-fixing crops and catch crops, which are deemed beneficial for water. Some countries have also banned the use of fertilizer and pesticides in these productive EFAs, further enhancing their potential benefits to water. Other relevant EFAs were offered, such as landscape elements (e.g. hedgerows and wood strips), afforested areas, agroforestry and maintenance of permanent grassland, but they were less popular amongst farmers.

Recent evaluations indicate that conditions attached to greening measures were also often not ambitious enough. Many EFAs for instance did not always go much beyond existing cross-compliance requirements (ECA, 2020; Devot et al., 2020). The European Court of Auditors (ECA, 2017) concluded that Member States used the flexibility in greening rules to limit the burden on farmers and themselves, rather than to maximise the expected environmental and climate benefit. Hence, no major changes at the farm level were required to receive the payment (Chartier et al., 2016; EC, 2017). Furthermore, their full potential were not always achieved because of lack of targeted advice to position them optimally at the farm and landscape level (BIOGEA, 2020)

The new green architecture proposes a Pillar I payment in the form of an “eco-scheme” to incentivise more sustainable land management through direct payments. This intervention is planned to be mandatory for all member states, but will be voluntary to the farmer. Because Eco-schemes tap into CAP Pillar I budget, Member States can mobilise more funding for incentivising sustainable farm practices and reach a much larger number of farmers (Lampkin et al., 2020).

### *Financing the transition to sustainable farming*

In addition to the compulsory elements of its green architecture, the CAP includes funding to support a range of rural development and agri-environment-climate measures under its Pillar II. Because of the high cost involved in transforming whole production systems, rural development has been a pivotal instrument in supporting the adoption of sustainable farm practices, from the adoption of new technologies to soil conservation practices, crop diversification, organic farming and agroforestry.

Under the WFD planning process, authorities have largely relied on RDP funding for the implementation of measures reducing pressures from the agricultural sector (EC, 2019a). Assessments of the inclusion of water measures into RDPs indicate that Member States have progressively increased their level of support over time (Mohaupt et al., 2007; Rouillard and Berglund, 2017). Box 4.7 presents the level of integration of water issues in the current RDPs 2014-2020.

The new CAP architecture proposes to keep this instrument, and rural development payments will remain an important mechanism to increase the adoption of sustainable farming practices. Drawing on the lessons from the current programming period, a number of observations on good practice can be made (Berglund et al., 2017):

- Some RDPs such as the one from North-Rhine Westphalia in Germany, prepared an in-depth initial “gap assessment” synthesizing water challenges, drawing on the latest data



and information from the RBMPs and FRMPs. This provided a good basis for selecting relevant priorities and measures in the RDP.

- Some RDPs financed innovative approaches to dealing with agricultural pressures. For instance, the Northern Ireland RDP in the United Kingdom financed the modernization of manure storage as well as nature-based solutions such as constructed farm wetlands, which can reduce the need for storage.
- When drafting their measures, some RDPs have gone further than the minimum legal requirements. More ambitious requirements include for example the requirement to save at least 25% of water if receiving support for improving irrigation efficiency (in Croatia), the establishment of buffer strips of 20m wider, or the prohibition of pesticide application in targeted areas.
- Some countries include explicit criteria for preventing harmful investments for water bodies. For example, Latvia funds in its RDP drainage schemes if they show compliance with the procedures of the WFD for assessing and preventing the deterioration of water bodies. Furthermore, it prioritises projects that include mitigation measures such as sedimentation ponds and wetlands.
- Some RDPs integrate climate adaptation and the need to build resilience in farming systems through appropriate crop diversification (e.g. Greek RDP) and adoption of drought resistant crops (Romanian RDP).

Safeguards are particularly important to avoid counterproductive RDP investments in areas of greatest pressure. For instance, it was still possible in the current RDP planning period to fund irrigation investments that could lead to an increase in irrigated areas or the uptake of more water intensive crops – resulting in increased consumption and lower return flows (Chapter 4.2.2) - in catchments with water bodies failing good status (Devot et al., 2020). Similar checks are needed on other investments such as drainage, the construction of reservoirs, and flood risk prevention measures.

The use of more water-relevant indicators in the Common Monitoring and Evaluation Framework could support a better assessment of the contribution of RDPs to water policy objectives – a task that was challenging under the current monitoring approach (Devot et al., 2020). Such indicators could track progress in nutrient and pesticide load reduction, improvements in morphological conditions, reducing water imbalances and meeting environmental flows.

The EU Biodiversity Strategy 2030 (EC, 2020d) calls for increase the area of organic farming to 25% of UAA by 2030. Organic farming is undergoing a significant growth, but total area remains at 7% of UAA in Europe. In January 2021 a new EU Basic Regulation on organic farming will come into effect and replace the existing legislation. The main benefit of the new regulation will be a further alignment of rules of production and control for goods produced in the EU and those which are imported. While this will further protect the standards held in Europe, greater policy support will be needed if the ambitious objectives of the Biodiversity Strategy is to be realized.

#### **Box 4.7 Planned water measures under the rural development plans 2014-2020**

The latest programming of the CAP Rural Development Plans offered a wide choice of measures to farmers wanting to reduce the pressures of their farm operations on the water environment. These included for example investments in assets (e.g. modernization of manure storage, water saving technologies, wetland and river restoration), agroforestry, agro-environment and climate operations (e.g. soil conservation technique, conversion of arable land into grassland) and organic farming. In addition, some Member States, such as



France, used compensation schemes for the compulsory uptake of measures supporting water policy (e.g. WFD, drinking water) objectives.

At European level, the RDPs 2014-2020 planned the following:

- 46% of RDPs' budget on Priority 4 was planned on Priority 4 "Restoring, preserving and enhancing ecosystems related to agriculture and forestry"
- 8% of RDPs budget on Priority 5 "Promoting resource efficiency and a low carbon and climate resilient economy"
- 15% of the agricultural land within their RDP area, equivalent to 21 million ha, was planned to under land management contracts to improve water management during the planning period. This varied greatly between Member States, with some planning to contract up to 80% of agricultural land under contract.
- 9% of irrigated land, equivalent to 776,842 ha, were planned to be switched to more efficient irrigation system.
- 36% of the budget of RDPs was to fund agro-environment and climate operations, with some RDPs going up to 83% of their budget.
- Almost most RDPs planned to fund organic farming.

Overall, the issue of water pollution from agriculture is well covered, and to a less extent abstraction and hydromorphological pressures. Most measures tackling water pollution from crops focused on more efficient use of fertilisers and pesticides through improved product application. Some measures put a limit on total use, sometimes targeting specific crop types such as fruit and vegetable crops, olive orchards and vineyards. More ambitious measures ban the use of pesticides. Measures on livestock focused on improve fertilization practices on grassland and feed crops, improved manure storage and wastewater treatment on farms. More ambitious measures, proposed in few RDPs, aimed to reduce stocking density.

RDPs planned to reduce abstraction pressures predominantly by improving efficient water use in irrigation systems and increased rainwater harvesting. However, this was rarely accompanied with ambitious targets for water saving, running the potential that most saved water would serve to irrigate more crops or more water-intensive but more valuable crops. Few RDPs supported the conversion to less water consumptive crops, selection of crops or varieties/hybrids with a lower water demand and more resistant to droughts, and application of water saving crop and soil management, which are important for adapting to climate change.

Less than half of RDPs supported changes in crop and soil management practices, such as crop rotation and low and no till agriculture. Few promoted more profound changes in land use, such as flood management, wetland creation, re-meandering or conversion to agro-forestry – although these measures could have multiple benefits to reduce pollution, abstraction and hydromorphological pressures.

Source: Rouillard and Berglund, 2017

### *Achieving uptake at basin levels*

The targeting of CAP payments towards areas of greater needs for improving the water stature has generally been limited until now. Direct payments were not targeted while farmers were free to choose their greening measures and their spatial implementation. RDP measures were voluntary and fewer farmers participated. However, to achieve a successful and environmentally effective transition, changes in land management need to be targeted to areas creating pressure, and, where necessary, should occur in a coordinated way across whole basins. Although good



practice in spatial targeting do exist (Box 4.8), incoherence and overlaps were observed in the types, ambition and targeting of measures under Pillar I and Pillar II instruments (Devot et al., 2020).

The new delivery model of the CAP provides an opportunity to improve the targeting of Pillar I payments, through the eco-scheme (Lampkin et al., 2020), and with better synergies between conditionality, eco-schemes, and RDPs instruments. This may be effectively reinforced thanks to the obligation to involve competent authorities for the environment and climate and the obligation to show greater ambition than at present with regard to care for the environment and climate (EC, 2020a). Using a results-based approach to eco-schemes and rural development payments where controls are made based on results instead of whether particular management actions have been implemented, would also enhance transparency in the delivery of objectives and encourage farmers to be more innovative in the processes that they use (Lampkin et al., 2020).

Collection action and multi actor approaches are supported under RDPs, and Member States have supported them in various ways, sometimes going beyond cooperation between farmers by integrating research actors and value chain operations (ENRD, 2018). The importance of integrating value chain actors is increasingly highlighted as a critical success factor in sustained uptake of crop diversification leading to reduced water pressures (Menet et al., 2018; Zakeossian et al., 2018). In Slovenia for example, beneficiaries of collective action measures include producer groups and agricultural cooperatives aiming to tackle diffuse pollution in catchments where water bodies fail WFD objectives (Berglund et al., 2017). Chapter 5 examines in more detail the role of the value chain in the transformation of agriculture towards more sustainable practices.

#### **Box 4.8 Spatial targeting in Rural Development Programme in France**

The agri-environment-climate measure in France is established at national level supplemented by strategies at regional (RDP level). The national framework requires that the regional agri-environment-climate strategy is coordinated with other regional and local plans, including RBMPs and other water management related plans in France (e.g. catchment management plans, territorial contracts of the water agency). One main mechanism to increase this coordination is through spatial targeting. Spatial targeting of M10 sub-measures occurs through two mechanisms.

A first prioritisation is presented in the RDP through the M10 agri-environment strategy. For example, in the Midi-Pyrenees RDP the M10 agri-environment-climate strategy targets the following water priority areas: 1) catchments experiencing water scarcity resulting in not reaching ecological flow targets, 2) drinking water protected areas, 3) water bodies in bad ecological status identified according to the characterization report from 2013, and strategic zones for future water use (drinking water, bathing water, wetlands).

The second level of spatial targeting occurs through “agri-environment-climate projects” (PAEC). Any M10 sub-measure (MAEC) must be implemented in the areas identified in the RDP (above) and covered by a PAEC. PAECs are sub-regional plans that aim to implement M10 sub-measures in a coordinated way in pre-defined sub-regions of the RDP region (e.g. a catchment).

The PAEC presents a valuable mechanism to improve the spatial targeting of RDP measures at landscape level.

Source: Berglund et al., 2017





## 5 Developing sustainable solutions

### Key messages

- Food and Energy systems are important drivers of the agricultural production. Demands within these systems has a large influence on specific choices of farmers, and ultimately on our ability to reach environmental targets.
- Managing sustainably in this context requires balancing the need for affordable products, social wellbeing and fairness, and the protection of the natural resource base, which in return will require explicit acknowledgement of systemic trade-offs.
- The newly adopted farm to for strategy provides leverage for changing systemic drivers such as consumer preferences and diets, but further attention is needed on other drivers linked to developing more sustainable agricultural systems, food supply chains, and to reduce food loss and waste.

### 5.1 More systemic responses are needed

Agricultural water problems have been resistant to policy interventions not only because of challenges in the implementation of environmental and agricultural policies, but also because the underlying drivers of agricultural production have been insufficiently tackled. These drivers are diverse, and include demand for food, energy and fibre. Without addressing these drivers, and the social, economic, political, institutional and technological systems that shape consumption patterns, it is likely that policy interventions will continue fixing the symptoms rather the roots of environmental degradation, which is most likely going to increase under a changing climate if no adaptation measures are taken.

#### 5.1.1 *European food systems and their pressures on the water environment*

##### *Food systems and water*

A food system can be defined as all the elements (environment including climate, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food and to the outputs of those activities, including socio-economic and environmental outcomes (HLPE, 2014).

European food systems today exhibit diverse characteristics across the continent. Small-scale family-based producers supplying short supply chains operate alongside large-scale globalised food companies and suppliers. However, European food systems have also evolved greatly during the 19<sup>th</sup> and 20<sup>th</sup> century, from predominantly local systems of exchange into complex international networks of production, consumption and trade.

Food systems create pressures on the water environment during the production of agricultural commodities, and along the whole processing, distribution and consumption chain. Assessments suggest that most pressures, through emission of nutrient and chemical pollutants and freshwater use, arise during the production of agricultural commodities, followed by industrial processing into food and drink products (Castellani et al., 2017). Water is also lost through food waste. In the EU, most food waste occurs at the distribution and consumption stage, totalling around 88 million tonnes of food along the supply chain, including the household level, with corresponding estimates as high as EUR 143 billion (Stenmarck et al., 2016).



### *Drivers in food systems*

Demography and diet are central drivers of the food system, and therefore influence significantly the overall impact of food consumption on the water environment, sometimes calculated as the land or water footprint of specific products. Europe is a major player in the global agricultural commodity market (Chapter 2) and therefore a major driver of consumption patterns.

Between 1950 and 2015, the EU-28 population increased from 380 million to 505 million (EEA, 2019c). while the average per capita consumption of animal protein is 50% higher than 1950 and double the current global average (Westhoek et al., 2011). Estimates suggest that the EU agricultural land footprint, i.e. the area of cropland and grassland necessary to produce the EU's food requirements, is about 203 million ha, of which 76% is associated with livestock production (Fischer et al., 2017). Not all of this area is in Europe, a large share of European consumption stems from outside the EU. The EU-28 food consumption footprint was equivalent to 17 million ha of cropland and 21 million ha of grassland outside the EU (Fischer et al., 2017).

European demand for food products, in particular meat and dairy, plays a role in agricultural production in Europe and worldwide. Dairy and meat production lead to large emissions of nutrients and chemicals (Chapter 3), but also results in water consumption, due to the large water quantity needed for animal feed. For instance, the production of bovine meat has the highest water footprint (i.e. 15,415 liters per kg of meat), compared with sheep and goat meat (i.e. 8,763 liters per kg), pig meat (i.e. 5,988 liters/kg) and chicken meat (i.e. 4,315 liters per kg), largely due to the difference in animal size and life span. Nearly 98% of the above water footprints for livestock refers to the water demand of crop production used as animal feed and grazing lands. In Europe, a large proportion of animal feed is imported, driving unsustainable water use in export countries (Rosa et al., 2019).

Overall, animal products represent 53% of the EU consumptive water footprint in food, followed by cereal and beer (11%) and vegetables, fruits nuts and wine (9%) (Vanham et al., 2013). Diets vary between European countries; thus the significance of different food products in the water footprint vary across Europe. The highest water footprint arising from food consumption is by southern countries, followed by eastern countries (Vanham et al., 2013).

#### **5.1.2 Other consumption systems and water**

Agricultural commodities are also used in the broader bioeconomy for the production of energy, textiles, paper, chemicals and pharmaceuticals. Bio-based products can be made from cereal, oil, sugar and fiber crops, straw and organic waste. Their production respond to different drivers than food products, and have in recent years received significant attention at EU level. Overall, the estimated cropland area for EU-28 consumption of non-food agricultural product is around 28 million ha and thus much smaller than for food products. Around 65% of the area is situated outside the EU (Fischer et al., 2017; Bruckner et al., 2019). In Europe, around 10 million Ha or 5% of the agricultural area is used for non-food agricultural products (i.e. bioenergy, textiles, chemical industry, etc).

### *Bioenergy and water*

Bioenergy refers to a range of energy sources based on biological matter. Bioenergy from agricultural sources are typically produced as liquid biofuels to work as substitute to diesel and petrol, from maize, rape, palm oil, sugar beet, and sugar cane. These first generation biofuels are complemented by a range of next generation, or "advanced", biofuels and bioenergy sources



which are assumed to require less input, be more resilient and produce higher yields. These energy sources draw energy from a larger range of agricultural products, such as energy crops from grasses and reeds, agricultural residues and waste streams (e.g. food waste).

Bioenergy is part of the energy portfolio of the European Union in its decarbonisation efforts and expansion in the use of renewable energy (EC, 2019d). By 2030, the EU aims to have at least 32% of renewable energy, and by 2020, it aims to have 10% of the transport fuel come from renewable sources such as biofuels. Fuel suppliers are also required to reduce the greenhouse gas intensity of the EU fuel mix by 6% by 2020 in comparison to 2010. The average share of renewable energy in transport in the EU-28 was 8% in 2018 (EEA, 2019j). which is mostly met through consumption of biofuels.

About 62% of the feedstock used in biodiesel and 79% in bioethanol originated in the EU in 2012, mostly from rapeseed, wheat, maize and sugar beet (Hamelinck et al., 2014). The remaining was imported as e.g. palm oil, soybeans and maize feedstock or as final product from various regions, including Indonesia, Argentina, US, Australia, and Malaysia.

Europe's production and consumption of bioenergy, in particular biofuels, has raised concerns about their environmental impacts in Europe and worldwide, for example through the expansion of agricultural land into biodiversity-rich and high carbon stock lands such as forests and peatlands (EC, 2019d; Strapasson et al., 2019). Estimates put European use of land for biofuel consumption at around 8 million ha (Hamelinck et al., 2014), while global consumption is associated with an estimated total of 81 million ha in 2011.

Concern is particularly high with regards to the large water demand associated with biofuel production. For instance, European production of bioethanol is associated with irrigated maize grown under water scarce conditions in Mediterranean regions and in France and Romania (Vanham et al., 2019). Assessments indicate that, of all energy sources used in Europe, biofuels generate the highest water footprint (Vanham et al., 2019).

However, it is also important to note that the water demand of imported biofuels is even greater, due to less efficient production methods abroad. Imports of biodiesel represent 64 billion m<sup>3</sup> of water compared to 1 billion m<sup>3</sup> from European sources. Overall, it is estimated that a majority of maize consumed for biofuel in Europe is produced under severe water scarcity (Vanham et al., 2019).

### *The wider bioeconomy and water*

Other bioeconomy value chains are based on a variety of crops and agriculture byproducts. Traditional fiber crops grown include cotton, flax, hemp, bamboo to make textile, but also building materials, cosmetics, medicines and chemicals. Cotton – a high water demanding crop – is by far the widest cultivated fibre crop worldwide, with more than 30 million ha corresponding to 80% of the global natural fibre production. Europe produces 1.2% of the world cotton. A range of new crops are being grown in Europe, such as miscanthus, giant reed, switchgrass and bamboo, which are low-input, high yields crops. They can be used for papermaking, building, biopolymers, and bioenergy purposes. Competition with synthetic material and a more favourable policy environment for food producing crops has nevertheless so far limited the growth of fiber crops.



## 5.2 The challenge of managing systemic trade-offs

### 5.2.1 *Growing demand, in an increasing resource limited world*

The EU has a long-term sustainability vision of 'living well, within the limits of our planet' by 2050. This means that consumption systems driving agricultural production should optimise outcomes between the need for affordable products, social wellbeing and fairness, and the protection of the natural resource base, maintaining and enhancing ecosystem health and resilience (EEA, 2017b). While the EU food system has been very successful in achieving its past objectives of food security and food safety, it has to date failed to deliver sustainability (EEA, 2017b; GCSA, 2020).

Globally, population growth and dietary change towards more meat and dairy based diets in emerging and low income countries are expected to increase demand for food in 2050 by 70% (FAO, 2009) or 56% more crop calories equivalent (Searchinger et al., 2018). Global cereal production would need to increase by 940 million tons to reach 3 billion tons, and meat production by 196 million tons to reach 455 million tons to meet future demand (Alexandratos and Bruinsma, 2012).

In parallel, demand for bioenergy and fiber products will also grow in response to climate mitigation targets and the drive towards a more circular bioeconomy. Under the EU's Bioeconomy Strategy, the Flagship initiative for a resource-efficient Europe and the Circular Economy Package, the EU's industrial policy aims to increase the bio-based product industry share to the EU GDP from 15% to 20% in 2020, stimulating primary production and conversion of waste into value-added products. Demand is thus expected to grow for biodegradable and recyclable materials to work as substitutes for chemicals based on fossil resources.

Climate change itself will significantly impact the distribution of natural resources essential for agricultural production such as water, and will impose drastic changes in climatic conditions in many world regions. Soil erosion, land degradation and desertification rates will put further constraints on global agricultural production (Shukla et al., 2019).

Under current trends and with no policy action, many expect that growing demand would require an increase in the area of farmland to meet future demand, or an increase in agricultural productivity on existing land, achieved in part through more intensive use of inputs such as fertilisers and pesticides. A "land gap" of nearly 600 million ha (twice as large as India) would be required to meet global demand (Searchinger et al., 2018). However, these developments would contribute to further loss of forest, wetland, peatland and other natural habitats, as well as higher pollution leaching, water consumption, soil degradation, land improvement and drainage pressures (Wirsén et al., 2010). If the present trend in worldwide consumption continues, it was estimated that two out of every three persons on earth will live in water – stressed conditions as soon as 2025 (WRI, 2019).

### 5.2.2 *Trade-offs for reaching environmental sustainability*

The use of nitrogen, phosphorous, pesticides and water in Europe over the last 30 years has become more efficient over the last 30 years (Chapter 3 and 4) and further efficiency gains are still possible without affecting productivity thanks to technological improvements and application of e.g. precision farming (e.g. Capper and Bauman, 2013). However, efficiency gains cannot on their own support the achievement of targets in the aquatic environment as resource use may remain too high to reduce pressure substantially (Matthews et al., 2018; Gerten et al., 2020).



The switch to more sustainable forms of agricultural production across all farming systems in Europe has large potential to reduce pressures on the water environment (Chapter 4). Modelling studies suggest that reaching a production that is sustainable with regards to nutrient flows can be achieved through adoption of agro-ecological production systems. It would also reduce financial risks to the farmers thanks to a diversification of production, and increased farm income thanks to price premiums on higher quality products. An additional benefit of these production systems is that agricultural greenhouse gas emissions are also reduced due to the lower livestock production (Poux and Aubert, 2018).

However, large scale adoption of agroecological practices would entail trade-offs. For instance, the same study it was assumed that agricultural land use would primarily be dedicated to crop production aimed at feeding humans rather than livestock, and that non-food production would be phased out. In addition, crop productivity would decline by up to 30% and livestock production by 40% (Poux and Aubert, 2018). Such levels of reduction in production and yields would disrupt existing farm systems and value chains (Chapter 5.3.1). It could also entail an increase in the price in agricultural commodities, which would impact the consumer.

Furthermore, a production system that delivers to primarily plant based diets, also requires a switch in dietary demands to one lower in meat and dairy intake. In an agroecological future, European diets would need to change significantly towards plant-based proteins, in order to avoid to further externalise meat and dairy production outside Europe (Poux and Aubert, 2018). Modelling studies at global level also indicate that reaching key planetary boundaries in nutrient flows, freshwater use and other environmental criteria is only possible if diets also change (e.g. Wirsenius et al., 2010; Westhoek et al., 2014b; Poore and Nemecek, 2018; Searchinger et al., 2018; Gerten et al., 2020). Consequently, sustainability cannot be achieved solely by changing agricultural production, but also changing consumption patterns (chapter 5.3.2).

The global need for changes in global production and consumption patterns are at the heart of the UN sustainable development goals, which underscore the interdependencies among many different societal factors, together with the potential gains of a more sustainable development trajectory. To reduce trade-offs and manage sustainable transitions, policy action needs to be systemic across production and consumption systems. In food systems for instance, this calls for solutions that involve not only producers but also food chain actors and consumers, and reorganise the whole food value chain (Westhoek et al., 2014b). This is explored in more depth in the next chapter.

### 5.3 Transitioning towards sustainability in food systems

The recent EU Farm to Fork Strategy (EC, 2020c) is a first step towards tackling the impact of agricultural production and food consumption in an integrated and systemic way. It foresees action on several dimensions, focusing on enhancing the capacity of Europeans to make informed, healthy and sustainable choices in their food environment, while increasing the efficiency of the food system. The Strategy takes into account targets for sustainable water management in its overarching objectives of reducing nutrient and pesticide use and, and boost the development of sustainable agriculture, in particular organic farming.

There are potentially numerous strategies to enable a transition towards sustainability in agriculture from a food system perspective. The following sections discusses three strategies that have been highlighted in the Farm-to-Fork Strategy and other publications on reforming of food systems towards sustainability (GCSA, 2020), in light of the agricultural production and its impact on the water environment:



- Changing supply chains to promote sustainable and more resilient agricultural system;
- Stimulate more sustainable diets to reduce demand for water-intensive food products;
- Reduce food loss and waste, and encourage their reuse and recycling.

#### 5.3.1 *Changing food supply chains to promote sustainable agriculture*

The structure of the value chain has important implications when designing responses to enhance the sustainability of agricultural production in Europe (Meynard and Messéan, 2014; GCSA, 2020). It also has a role to play to increase food system's resilience to climate change by planning adaptation pathways not only for the production sector (farming systems) but also for investments into infrastructure for collecting, storing and transforming agriculture commodities (ADEME, 2019). Risks with adopting agro-ecological practices, diversifying production and adapting to climate change must be shared between farmers and value chain actors.

Value chain operators have optimised collection, storage and processing infrastructure according to cost reduction targets and economies of scale needed to compete on national, international and global markets (IPES Food, 2016; EEA, 2017b). Diversifying crops or switching to organic farming imply upfront costs to adapt and expand the specific supporting infrastructure as well as higher running costs on lower volumes of agriculture commodity. These difficulties can represent a major barrier for the expansion of organic farming or the diversification of farm production in specialized regions (Meynard and Messéan, 2014)

The importance of enabling changes in agricultural production through a value chain logic is increasingly emphasised (Meynard and Messéan, 2014; IPES Food, 2016). It calls for high level of collective action between relevant actors and better structuring between agri-food sectors (Zakeossian et al., 2018). EU Rural Development Programs have in some case supported such collective action. In Greece for example, authorities supported greater coordination between durum wheat processing plant operators and local cotton producing farms to initiate a transition from cotton production towards durum wheat production, leading to a reduction in water consumption. In Cyprus, potato farmers were encouraged to switch to less water-demanding fodder production in response to increased demand from livestock farmers faced with rising prices for imported feed.

Other strategies are possible to overcome the cost of creating the infrastructure for the collection, storage, and transformation of diversified crop production or organic farming. For example, preferential loans or subsidies for investments into infrastructure supporting diversification in specialised regions or to facilitate the development of organic farming have been provided, for example through RDPs (Zakeossian et al., 2018). Cities and municipalities have also created their own collection and storage food cooperative to supply organic food to public canteens.

The value chain can play a valuable role in changing agricultural practices in other ways. The food industry have increasingly established product specifications which farmers must follow to access markets (Fresco et al., 2016). These standards, in the form of production contracts and labels, typically include assurances that specific crop and livestock operations will be carried out and that final product delivery meet the desired quantity and quality. Integrating results-based, environmental performance in these standards, and rewarding it accordingly to account for potential higher production costs, can act as a major leverage on agricultural production. Some food operators, have integrated ambitious programmes. The CAP could support further expansion of such private schemes (Fresco et al., 2016).

CAP support schemes have encouraged adoption of more environmentally friendly practices, and such support schemes could go further in supporting the transition. However, the uptake of



more sustainable farm practices will only last if the market takes over from public action. The higher costs of producing more sustainably can be covered through product differentiation, and the use of certification and labels (ADEME, 2014; Meynard and Messéan, 2014). Alternatively, the greater use of minimum sustainability standards on food products can support a broader and more systematic market uptake by levelling the playing field. The Farm to Fork Strategy (EC, 2020c) proposes to progressively raise sustainability standards of all food products placed on the EU market and support certification and labelling approaches.

A number of public and semi-public interventions are increasingly used to provide alternatives to compensation schemes provided under the CAP (Chapter 4) or overcome the lack of intervention from private food chain operators. Public and private drinking water providers across Europe have initiated schemes based on payments or the buying and leasing of agricultural land, to incentivise more sustainable forms of production on drinking water protected areas (Thomson et al., 2014; Cook et al., 2017).

Under the EU Farm to Fork Strategy, the Commission plans to determine the best modalities for setting minimum mandatory sustainability criteria in public procurement. This can represent a significant leverage for expanding supply of more sustainably produced food and promote sustainable diets in schools, public institutions and collective canteens (Renting and Wiskerke, 2010; IPES Food, 2016). Some cities seek co-benefits to preserve the quality of their drinking water supplies by targeting public food procurement contracts to producers in drinking water protected areas, and thereby incentivise uptake of more sustainable forms of agriculture.

### **5.3.2 *Moving to sustainable diets to reduce water use and emission of pollutants***

Recent years have seen an acceleration of the adoption of less water resource-intensive diets, by reducing meat consumption and increasing the share of vegetables and plant-based products. To reduce nutrient emissions and water use involved in growing feed crops and rearing livestock, diets should cut meat and dairy consumption, and increase the intake of plant-based and other protein types.

Estimates suggest that the water footprint of food consumption could be reduced by up to 41% by a switch to vegetarian diet in southern European countries and 30% for a switch to a healthy diet, and respectively 32% and 3 % in northern regions (Vanham et al., 2013). Studies on the effect of diets on nitrogen emissions suggest that halving meat, egg and dairy consumption in the European Union could achieve a 40% reduction in nitrogen emissions, assuming corresponding changes in livestock agricultural production (Westhoek et al., 2014b).

Demand from consumers is a fundamental driver in food system. However, consumer preferences are also shaped by the food system and constrained by norms and conventions, cost, convenience, and habit, and the ways in which food choice is presented (EEA, 2017b). Influencing the food environment could be an important lever for change with regard to dietary composition and supporting more environmentally sustainable production. Awareness-raising campaigns and food labelling have role in influencing choices and behaviours, but a food environment conducive to sustainable diets would shift costs on unsustainable choices and make sustainable choices the easiest option (GCSA, 2020).

The EU's Farm to fork strategy does not commit to stop stimulating production or consumption of meat, but it offers support for alternative proteins and a move to a more plant-based diet. It proposes to strengthen food labelling standards to support consumers in making sustainable diet choices, including most efficient meat production but also alternative protein diets based for instance on plants.



Targets can also be set to support greater adoption of sustainable diets in collective catering centres. For example, the Law for on trade relations in the agricultural and food sector in France aims for 50% of sustainable food products in collective catering centre, including 20% of organic food by 2022. Other instruments have been proposed, such as taxation of animal products (Vinnari and Tapio, 2012) or the expansion of short supply chain (Box 5.1).

Although the capacity of short supply chains and alternative food networks to meet the challenges of feeding the European population is often questioned, their role in fostering more sustainable eating habits and wellbeing is well acknowledged. Short supply chains have several advantages, from supporting the emergence of new local outlets and more diversified agricultural production, to increasing the value of agricultural products, improve producer income and enhanced social cohesion, and reducing CO<sub>2</sub> emissions because of less transport ways.

#### **Box 5.1 Short food supply chains**

Short food supply chains, such as the direct distribution of agricultural products, collective direct sales and partnerships lead to a regionalisation of markets and can reduce the farmers' dependence on large scale, powerful retailers. Short food supply chains can reduce competition and increase farm income. Furthermore, short food supply chains can strengthen the local economy and help to keep family operated and small farms in business.

There is a great diversity of short food supply chains and local food systems in the EU. Short food supply chains and local markets have flourished here in recent years, both in rural and urban areas. On average 15% of EU farms sell more than half of their production directly to consumers through these short supply chains in 2015. In 2015, local food systems provided food for almost half a million Europeans, in particular in France, Belgium and Italy. Short food supply chains tend to be characterised by full or partial organic farming, but they are not always certified.

The rural development program 2014-2020 puts more emphasis on short food supply chains. Several measures are co-financed by the European Agricultural Fund for Rural Development to help in setting up and developing short food supply chains and local food systems through support for investment, training, the LEADER approach and organisation of producers.

Source: Kneafsey et al., 2013; IPES Food, 2016

### **5.3.3 Reducing food waste to increase water use efficiency across the supply chain**

An estimate 20% of food is wasted in the EU, of which as much as half is lost at household level (Vittuari et al., 2016). The remaining is lost in processing (19%), food services (12%), production (11%) and wholesale and retail (5%). Reducing food waste thus requires tackling losses that occur during separate steps of the food system involving different actors and very different waste processes. The recent Farm to Fork Strategy (EC, 2020c) calls to cut food waste at retail and consumer levels by half per capita by 2030, and reducing food losses along the food production and supply chains. Global water savings of approximately 250 km<sup>3</sup> of water each year may be achieved by reducing food waste (FAO, 2013).

Waste reduction is tackled at EU level by the Waste Framework Directive (Directive 2008/98/EC)(EU, 2008b). EU Circular Economy policy (EC, 2020b) encourages the adoption of a circular model, which applied to food systems, would encourage not only waste reduction based on lower production and consumption levels, but also reuse and recycling of irreducible food



waste. The valorisation of food waste aims to reintroduce food waste into the production cycle, which could further reduce demand for additional primary commodity.

This integrated approach to food waste management should account for a number of critical issues from a water and agricultural perspective. First, there needs to be an emphasis on the recovery of nutrients. An estimated 80% of nitrogen and 70% of phosphorus are wasted across the food system. Most of these losses occur at production level and warrants adequate measures for reducing leaching and recycling of nutrients at farm and local level. Increased efficiency in nutrient use is also possible via recycling of food waste as animal feed or as compost at the food processing and retailing stages. Wastewater reuse can exploit household losses after consumption as sewage sludge for field application and irrigation water. The Sewage Sludge Directive (EEC, 1986) and Water Reuse Regulation (EU, 2020) encourage these practices.

Alternative approaches would enhance synergies between food and energy systems. Technologies for biogas production exist to exploit crop waste and manure, and increase nutrient recycling at farm and local level. This solution can also reduce farm energy costs and represent an additional source of income. Waste along the food chain could also be exploited by larger units.

## **5.4 The need for policies supporting systemic responses**

To move towards sustainability, future policy responses will need to be systemic and maximise opportunities for positive environment change along the whole agricultural production and linked consumption systems (EEA, 2019h). In the past, much of the European policy framework tackling agricultural pressures on the water environment has focused on regulating agriculture, and less so on tackling drivers in food and energy systems, and the broader bioeconomy. More integrated responses would aim to align water, agricultural, food, energy, climate, trade, and other environmental and sectoral policies, considering transversal and cross-cutting dimensions (FAO, 2014; Venghaus and Hake, 2018).

In recent years, there has been a shift towards greater policy coherence and integration, and tackling Europe's challenges in a systemic way. The Farm-to-Fork Strategy is an example for such systemic policy thinking. Decoupling environmental degradation and economic development - and moving to a greener and more resource efficient economy - has become a priority, but requires implementation and more needs to be done to become more sustainable. This transformation will also be needed to adapt to the impacts from climate change.



## 6 The way forward

The transition towards sustainability at the interface between water and agriculture will be a challenging task that will not be solved by traditional policy interventions. Responding more effectively to sustainability challenge will require a better understanding of the conditions and mechanisms that drive agricultural production, with particular focus on consumption systems around food, energy and fiber. This report documents that across Europe the agricultural production associated with pollution, water abstraction, and hydromorphological pressures, the drivers leading to these pressures, that an elaborate system of management measures is available but also points towards potential improvements in management and policy. Responding to these challenges is becoming urgent, since climate change impacts in parts of Europe are becoming strong enough to potentially jeopardise water availability for crops, increase pollution, and hydromorphological pressures, putting the agricultural production itself at risk.

In past decades, more resource efficient farming practices have been adopted in European farming systems, which has contributed to the levelling of pressures. However, as also documented in Chapter 3, the system remains far from sustainable. Less resource demanding farming systems may be needed to further reduce pressures on water, and, although not a subject in this report, they would also benefit biodiversity, soils, and climate change mitigation. Such systems would further enhance the resilience of the agricultural production to climate change.

Identifying the target for a more resilient and sustainable production remains a challenge. One approach could be to explore limitations for resource use at the basin scale, establishing the capacity of the natural environment to absorb pollution, recycle nutrients and provide water to agroecosystems. Establishing such limits for basins would help to better understand how much agricultural production can be sustainably produced in terms of crop yields and livestock, given the capacities of the basin. It is rather likely that production levels would be lower than what the current systems provide, and hence has implications for farmers' incomes, food prices, and availability.

The uptake of more sustainable farming systems in return, depends critically on being attractive to the individual farmer and the actors of the value chains benefiting from agricultural production. Thus, developing a more sustainable agricultural production cannot be seen in isolation from consumer demands and overall market forces. The European and global consumer preferences by individuals and industries are extremely important drivers for food production and its prices. These interlinkages are very challenging to manage without developing unintended consequences. However, this is what is required to make progress along the objectives of the European Green Deal.

With its ambitious policy initiatives, including the proposed EU Climate Law, Adaptation Strategy, Biodiversity Strategy, the Farm to Fork strategy, and the Zero Pollution Action Plan, the European Green Deal has articulated the ambition to move Europe on to a more sustainable development path

Sustainability is a central concept in these policies, but although clear messages are passed in terms of targets, a better understanding of how to get there is needed. For example, aiming for



organic farming on 25% of the agricultural land area is a powerful and clear objective set in the Biodiversity 2030 and Farm to Fork Strategies, but a better understanding of the systemic challenges that need to be overcome to achieve the target is needed. Clearer and more systemic definitions of sustainability are warranted to move the overall production and consumption systems in this direction. Sustainable solutions will not be realised by targeting change in one area, but by a large scale and probably long term effort to jointly restore nature, improve efficient resource use, implementation of more sustainable farming practices, and changing consumer demand and other drivers from consumption systems.

As part of making progress towards more sustainable agriculture, this work points to four areas of improvement: more resilient management actions, improved implementation and integration of EU policies, more holistic approaches through systems thinking, and better knowledge systems.

## 6.1 More resilient management actions at basin and farm level

This report has shown that a wide variety of management measures exists to tackle agricultural pressures on the water environment. To date, most measures implemented have sought to improve water management and increase the efficiency of resource use in agriculture. This has resulted in significant improvements and, in some cases, a stabilization in the exponential growth in agricultural pressures observed earlier in the 20<sup>th</sup> century. While some decline in pressures and water quality improvements have been observed, the current level of resource inputs (water, nutrients, and pesticides) remain unsustainable.

There is, however, still significant room for additional environmental improvements from increased resource use efficiency. Reaching WFD environmental targets will require more ambitious uptake of sustainable agricultural production aiming to reduce overall resource use. Furthermore, in the coming period, the impact of global warming on water resources is likely to become stronger. It will result in an increased level of unpredictability and uncertainty for farmers and public authorities alike. This places more urgency on the need to develop resilient approaches in agricultural production, or pressures to the surrounding environment will continue to increase. At the same time, adaptive management is needed to secure development of best practices. Resilient management action has been divided into three categories: improving management of sustainability and resource efficiency, developing improved resilience and risk management strategies, and recognising and managing complexity. Many of these recommendations could be picked up by existing policy processes for further streamlining across Europe.

### Improving management of sustainability and resource efficiency:

- **Enhancing efficiency in use of nutrients, pesticides and water.** Wide scope for improving nutrient use efficiency in production and within the food chain. Large scope to optimize use of pesticides. Scope for improving water productivity (more crop per drop). Although precision farming has big role in future farming, need to acknowledge limitations, as an efficient but large consumption of fertilisers, pesticides and irrigation water will still induce large pressures.
- **Further specify sustainability standards at river basin and farm level to put limits on resource use—** each river basin and aquifer – and their agricultural land management—have unique biophysical, social and economic conditions. There is not a one-size fit all



response – hence general sustainability principles must be transcribed into local conditions to make it operational to river basin authorities and farmers. This implies setting targets for water management and agricultural practices. Water management targets could include targets for basin-wide reduction of nutrient loads or maximum volumes of water that can be abstracted in a particular basin. Similarly, targets for good agricultural practices could include targets for organic farm area, nutrient application standards, integrated pesticides management, and irrigation application rates.

#### Developing improved resilience and risk management strategies:

- **Managing uncertainty explicitly by promoting no-regret options.** In an uncertain future, it is important to avoid costly investments which may not provide anticipated levels of return. Hence, ecosystem restoration and landscape approaches that provide multiple benefits (e.g. restoring floodplain dynamics, restoring landscape-wide natural infiltration) may be more cost-effective than costly, large infrastructure development (e.g. reservoirs).
- **Managing risks not yield** - Need to move away on focus on inputs and yields, but instead focus on risk management and multiple benefits delivered at farm and landscape level. One example is on adapting to water scarcity and drought: need to manage rainfall, soils and evapotranspiration by designing the right rainfed practices and diverse agricultural systems. Building resilience in agroecosystems by reducing reliance on input, increasing internal recycling, and diversifying production support this.

#### Recognising and managing complexity:

- **Recognising the complexity of management of water in agriculture, in an adaptive management approach.** Establishing sustainability standards will be prone to scientific challenges and uncertainties. Furthermore, agroecological techniques are strongly dependent on local contexts, and designing the right approach will need trial-and-error. Adaptive management will ensure regular revision of knowledge and practice based on best available science. Knowledge systems will need to be developed that provides a better understanding of scale of pressures (e.g. level of application of pesticide, metering and monitoring of water use) and ensure this knowledge informs RBMP and CAP implementation.
- **Accompanying transformations at farm level in an integrated way.** Farmers will need support to identify how to diversify production effectively reducing pressure while increasing their physical, economic and social resilience to global change. But they will also need adequate signal from market actors in the food and other consumption systems. Support to collective approaches between farmers, food chain actors, authorities and consumers and citizens will be needed to mutualise risks and capacities, promoting social learning, and engage in a systemic transition at multiple levels.

## 6.2 Improved implementation and integration of EU policies

The EU has a comprehensive environmental policy framework, developed over decades, that has contributed to tackle agricultural pressures on the water environment. A lack of enforcement has however impeded their successful implementation. At the same, the Farm to Fork and Biodiversity Strategies have established new ambitious targets:

- To reduce nutrient losses by at least 50% while ensuring that there is no deterioration in soil fertility (this would reduce use by 20%)



- To reduce by 50 % of the overall use and risk of chemical pesticides and the use of more hazardous pesticides by 50% by 2030
- To reduce by 50% in sales of antimicrobials used for farmed animals and aquaculture
- 25% of agricultural land organically farmed by 2030
- 10% agricultural area as high diversity landscape features by 2030
- To achieve EU commitments on land degradation neutrality, including action on soil sealing, soil contamination, soil health and functions

To achieve these targets, greater coherence is needed between EU environmental policies and the sectoral EU policies supporting agricultural production. Recent decades have seen improved integration of water targets in the Common Agricultural Policies. However, future agricultural policies need to be more ambitious on the scale of change needed in production systems. More systemic attention is needed to the ways CAP regulatory and incentive instruments support transition in farming production coherent with environmental goals. The main tools available to manage this challenge for water is a combination of the river basin management plans and the new CAP strategic plans.

#### **Better enforcement of existing policies:**

- **Reduce non-compliance with existing requirements.** Several gaps remain in the implementation of existing environmental legislation. There needs to be more systematic registration, licensing and monitoring of agricultural water abstraction –and avoiding illegal water abstraction. Exemptions should be avoided in the implementation of the Nitrates Directive, in particular regarding limits to fertilizer and manure application. Adoption of integrated pest management by farmers should be mainstreamed, for example by strengthening requirements in future CAP cross-compliance.
- **More coherent implementation.** Environmental legislation is not always fully reflected in agricultural policy. Remaining CAP Pillar I support payments to high input systems should be avoided. Under Pillar II, support to farming systems posing risks to the water environment should be avoided to lock-in into particular intensive production modes. For instance, investments into irrigation efficiency should be made conditional with uptake of water efficient crops and safeguards to avoid increase in water use. Furthermore, the preparation of CAP Strategic Plan and their implementation should integrate fully the information, indicators, priorities and measures stemming from the relevant RBMPs.

#### **More ambitious design of support instruments:**

- **Consider efficient resource use as the baseline requirement for any farming system.** Efficiency standards in the use of nutrients, pesticides and water are needed and could be integrated in the framework of CAP cross-compliance. This would further mainstream best farm management practices, and redirect CAP resources to supporting the transition towards agroecological measures in ecoschemes and RDPs.
- **Upscaling the support to agroecological principles throughout the CAP.** The ambition of crop diversification and rotation measures in CAP Pillar I eco-schemes should be high. Support to the adoption of organic farming and other forms of sustainable agricultural systems in CAP Pillar II should be vastly expanded (support rate and budgetary envelope). CAP Strategic plans should adequately identify priority basins with regards to agricultural pressures under the RBMP, and ensure the implementation of eco-



schemes and Pillar II RDP payments are targeted towards those areas. Results-based payments schemes could ensure that needs, ambition and results are aligned.

- **Strengthen areas that currently lack a strategic approach to tackling pressures and drivers.** This is relevant for instance regarding management of water use in agriculture, since the EU does not yet have an overarching approach to strengthen the resilience of agriculture to scarcity and droughts. Such strategy would need to increase resilience through agroecological principles and consider resource limitations at river basin level. Similarly, the restoration of aquatic ecosystems, and how to tackle agricultural pressures (drainage, livestock, irrigation infrastructure), will need to be at the core of the future EU Nature Restoration Plan.
- **Ensure that RBMP and CAP measures on water and agriculture are climate-proofed.** This means avoiding costly infrastructure investments if future benefits are uncertain, and invest in no-regret measures that increases overall resilience and provide multiple benefits. These solutions include agroecological forms of agriculture that preserve and enhance soils, as well as landscape approaches and nature-based solutions. CAP support payments should be directed to type of production and investments that will be coherent with future climate impacts on water resources and crop production.

### 6.3 Mainstreaming systems thinking to improve management

It is not possible to achieve water targets without a combined approach to change both agricultural practices and consumer demand and this needs to be supported by a transition in food and energy systems. Food and Energy systems are important drivers of the agricultural production. Demands within these systems has a large influence on specific choices of farmers, and ultimately on our ability to reach environmental targets. Managing sustainably in this context requires balancing the need for affordable products, social wellbeing and fairness, and the protection of the natural resource base, which in return will require explicit acknowledgement of systemic trade-offs.

The newly adopted Farm to Fork Strategy provides leverage towards a sustainable food system, and it calls for changing systemic drivers such as consumer preferences and diets, but further attention is needed on other drivers linked to developing more sustainable agricultural systems, food supply chains, and to reduce food loss and waste.

#### Support the transformation of production systems through the food chain

- **Prepare a coordinated policy to increase the production of, and market for, plant-based proteins** – from production to consumer by supporting farm level transitions through investments in infrastructure for alternative protein food products and consumer awareness raising.
- **Integrate food system perspective in national and regional water, agriculture and food policies.** For instance, CAP strategic plans should actively support infrastructure investments in the food chain (storage, food product transformation unit) to support a diversification of agriculture. This could be coordinated with water and environmental policies to target sustainable investments in priority areas for the WFD, i.e. target drinking water protected areas. Procurement contracts for supplying food to institutions could be used to support local production of organic food.
- **Ensure that investments in the food chain are climate proofs.** Hence, new food chain infrastructure investments should be coherent with the production patterns of a



resilient agriculture under climate change, e.g. they support diversification of production and support crops that are more resistant to droughts.

#### Re-orient demand towards sustainable consumption patterns

- **Stimulate demand for products from sustainable farming** by consumers: labelling schemes and regulations to promote green products that minimise footprint on water and land.
- **Reduce food waste and enhance circularity in the food chain, to reduce demand for primary agricultural products**, e.g. using food waste for bioenergy instead of using intensive bioenergy for energy production
- **Align agricultural, trade, environmental, and climate policies** to avoid displacement of environmental impacts outside the EU and protect higher environmental standards in European agriculture.

## 6.4 Closing remark

The path of sustainable development will be a complex one. It requires a much deeper understanding of large scale links – those between the food and energy systems, the agricultural sector, and in this case the objectives of water policy – than available at present. To achieve a sustainable transformation in the water and agriculture domain, decision-making will need to be supported by robust knowledge systems and innovation to provide understanding of the scale of changes needed and to create incentives for new responses. Experimentation and learning will be essential.

The scale of challenges facing Europe to reach sustainability at the interface between water and agriculture is enormous. The same ambition that underpinned the modernisation of agriculture in the post World War II period is needed to achieve a more sustainable agricultural system. Conventional techniques have benefitted from 70 years of mainstream research and development. Agroecological techniques will also need significant financial and technical resources to achieve required large-scale uptake to reduce agricultural pressures on European water resources, biodiversity, soils, and climate and time will be needed to reach their full potential. The Green Deal provides fresh opportunities to engage in this transition, and, if fully implemented and operationalised, the new ambitious targets should provide the new impetus needed to move towards a more resilient and sustainable future.



## List of abbreviations

Abbreviation	Name	Reference
EEA	European Environment Agency	<a href="http://www.eea.europa.eu">www.eea.europa.eu</a>



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## Annex 1 (repeat sequentially for subsequent annexes)

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### **Figure/Map/ Table/Box A1.1 Caption**

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**Photo A1.1 Caption** (for photos only, the caption comes under the feature)

### **Figure/Map/ Table/Box A1.2 Caption**

Insert feature here. For figures, maps and photos insert as .jpeg, .png file.

**Photo A1.2 Caption** (for photos only, the caption comes under the feature)

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