STUDY

Requested by the AGRI Committee

European Parliament

The impact of extreme climate events on agricultural production in the EU

Agriculture and Rural Development

Policy Department for Structural and Cohesion Policies
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RESEARCH FOR AGRI COMMITTEE

The impact of extreme climate events on agriculture production in the EU

Abstract

The study aims, first, to provide the European Parliament with an overview of the challenges faced by the agricultural sector regarding the evolution of climate extreme events in the European Union. Then, the study highlights existing solutions to help farmers mitigate the effects of extreme weather events and recover from climate-related disasters. Finally, it analyses existing policy instruments supporting these solutions, including those promoted by Member States under the new CAP programming (2022-2027)

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LIST OF ABBREVIATIONS

AGRI	Agriculture and Rural Development Committee
AECM	Agri-environmental and climate measures
APR	Annual Performance Report
ASD	Area-specific disadvantages
CAP	Common Agricultural Policy
CCIV	Climate Change Impacts and Vulnerability assessments
CSP	CAP Strategic Plan
CMO	Common Market Organisation
DMP	Drought Management Plan
EAGF	European Agricultural Guarantee Fund
ECMWF	European Commission and the European Centre for Medium-Range Weather Forecasts
EDO	European Drought Observatory
EEA	European Environment Agency
EEU	Eastern Europe
EU	European Union
EUR	Euros
FRMP	Flood Risk Management Plans
GAEC	Good Agricultural and Environmental Condition
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ha	hectare
IPCC	Intergovernmental Panel on Climate Change

LER	Land Equivalent Ratio
LULUCF	Land use, land use change and forestry
MED	Mediteranean
MPCI	Multi-peril crop insurance
MS	Member State
NAP	National Adaptation Plan
NAS	National Adaptation Strategy
NEU	Northern Europe
NSF	National Solidarity Fund
ONERC	French National Observatory on the impacts of Climate Change
PMEF	Performance Monitoring and Evaluation Framework
RBD	River Basin District
RBMP	River Basin Management Plans
RCP	Representative Concentration Pathway
RDP	Rural Development Programme
RMT	Risk Management Tool
SO	Specific Objective
SPEI	Drought magnitude index
SSAC	Spanish Combined Agricultural Insurance System
SEU	Southern Europe
UAA	Utilised Agriculture Area
WFD	Water Framework Directive
WCE	Western and Central Europe

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EXECUTIVE SUMMARY

This study examines how the experienced and projected increase of extreme weather and climate events throughout the EU territory impacts the agricultural production in the EU, hence triggering adaptive solutions by the sector and possible policy responses to make agriculture more climate-resilient. It provides an overview of the impacts of extreme weather events that can be associated with climate change and available solutions for the agricultural sector. It also examines to which extent the actual policy instruments pro-actively support the adaptation of the agricultural sector, both at EU and national levels and provides best practice examples drawn from case studies on how to further contain the adverse effects of climate change for agriculture.

Observed trends in the occurrence of extreme climate events and impacts on EU agricultural sector

Phenomena such as heatwaves, cold spells, heavy rains, storm surges, flooding, landslides, droughts, wildfires and intense storms (wind, hail) can be termed extreme events. When such phenomena occur simultaneously, they are referred to as compound events. Climate change may influence the frequency and severity of extreme events, this attribution being particularly clear-cut for heatwaves. Historical and projected trends in the occurrence and the severity of extreme events converge towards similar pictures: an increase in extremely hot summer temperatures over all of Europe, progressively drier conditions in the South of Europe, and an increase in heavy rainfall episodes in Northern and Central Europe. The magnitude of these increases is concerning. The number of climatological heatwave days will see at least a fivefold increase by the end of the century in the coolest climates, and up to thirty times more in warmer climates. Drought severity in Southern Europe could triple by the end of the century.

Losses specific to the agriculture sector account for more than 60% of drought-linked losses, or around €5 billion annually (based on Naumann et al, 2021). This is projected to increase in the future. Extreme events also have cascading consequences on ecological functions and on farming economics. Vulnerable sub-sectors include non-irrigated cereals, and specifically maize; fruit trees and perennials; tubers grown in regions with heavy precipitation extremes; and livestock for its dependence on green fodder.

Adaptation solutions for the agricultural sector to become more climate-resilient

To support farmers and maintain productivity, several adaptation options exist. "Top-down" adaptation options include risk management tools (insurance, mutual funds, hedging, or risk pooling), climate change observatories, and early warning systems implemented by local authorities. Farmers may also adapt autonomously ("bottom-up") by adopting one or several adaptive strategies: income stabilisation by adhering to risk management schemes or diversifying revenue sources, resilience building through improvements to soil health and healthy functioning of the agroecosystems, or asset protection through investment in specific equipment (hail nets, greenhouses, irrigation, etc.)

Policy instruments supporting the adaptation of the EU agricultural sector

European strategies (Farm to Fork Strategy, EU Adaptation Strategy, EU Biodiversity Strategy for 2030, EU Soil Strategy for 2030, etc.) promote a systemic approach of environmental and climate issues considering the role and potential effects on the agricultural sector. However, the provisions set by EU policies (e.g. for efficient water use by the agricultural sector) are not yet sufficiently implemented by Member States to address climate change issues faced by the agricultural sector. Moreover, synergies between flood risk management policies and agricultural policies are still limited.

The new CAP reform is putting increasing emphasis on instruments supporting proactive management of the effects of extreme weather events caused by climate change. The analysis of CAP strategic plans reveals that Member States considered the need to support adaptation of the agricultural sector to climate change as a priority. To respond to the challenges of adaptation, instruments most widely applied by Member States in their CAP Strategic Plans are eco-schemes, sectoral interventions, ENVCLIM interventions and INVEST interventions.

The most widely supported adaptation solutions that contribute to the prevention of flood damage are practices favourable to soil structure (promotion of rotations, increase of plant cover and limitation of tillage), but also the maintenance or establishment of landscape elements such as hedges or buffer zones. With regard to the prevention of damage due to drought and water scarcity, Member States mainly support solutions that promote a more efficient use of irrigation water, solutions that increase water retention in soils and the landscape, and measures targeting crop rotation, crop diversification and the adoption of more drought- and heat tolerant species. Some Member States are also supporting improved pasture management, for example by matching stocking densities to forage production, in order to address the risk of forage shortages in the event of drought. Finally, other adaptation solutions target the risks of frost, hail and storms, such as promoting hail protection for orchards.

However, the CAP measures implemented by Member States were generally not designed in a comprehensive approach enabling massive and general adaptation of the agricultural sector. CAP interventions promote the adoption of individual farm practices and management measures addressing specific climate risks ("1 practice = 1 payment"), rather than fostering systemic approach at farm or territorial level.

While some countries plan to adopt newly developed approaches to risk management tools, the relatively weak mobilisation of the CAP to support their deployment should be underlined. To date, risk management tools are very rarely cited as instruments that specifically address adaptation of the agricultural sector to climate change (Specific Objective 4 of the CAP on contribution to climate change mitigation and adaptation (SO4)). Rather, they are seen as tools to increase the overall resilience of the agricultural sector (Specific Objective 1 “Support viable farm income and resilience of the agricultural sector”).

Finally, as these policy instruments remain voluntary, their potential impact will depend on the allocated budgetary resources and the uptake by farmers. Member States will need to assess the effectiveness of their CAP strategic plans on climate change adaptation and implement the necessary adjustments for the achievement of SO4 objective (Contribution to climate change mitigation and adaptation).

Notably, the annual reporting of results indicators relevant to climate change adaptation (e.g. share of utilised agricultural area under supported commitments to improve climate adaptation) required by the Regulation (EU) 2022/1475[1] should enable to monitor the progress achieved.

Recommendations

It will be crucial to analyse in the coming years which instruments have been effectively mobilized by each Member State, to support the adaption of the European agricultural sector to climate change. The analysis highlighted that the adaptation objectives set by Member States should be defined more precisely to enable proper monitoring of the results achieved. Moreover, it will be important to assess the ability of the Performance Monitoring and Evaluation Framework (PMEF), applicable for the CAP from 2023 until 2027, to report on the contributions of each CSP (CAP Strategic Plan) to this European objective.

To improve the resilience of EU farming systems to severe climate events, systemic approaches at farm level should be fostered by CAP interventions. In this regard, specific mechanisms, e.g., point-based, result-oriented, and system-based approaches, should be more developed in the CSPs, to target ambitious adaptation solutions.

More effort should be done on supporting the deployment of risk management tools. However, support for insurance schemes is an ex-post measure (supporting recovery from an adverse climate event) that should not overshadow ex-ante measures (promoting prevention, preparedness and response) at farm level.

Finally, synergies between water management policies, agricultural policies and climate policies need to be strengthened, through a better integration of flood risk management and drought risk management into CAP strategic plans.

[1] Commission Implementing Regulation (EU) 2022/1475 setting out the rules for implementing Regulation (EU) 2021/2115 on the evaluation of the CAP Strategic Plans and the provision of information for monitoring and evaluation.

1. INTRODUCTION

This past June 2022 was the third warmest on record globally. In Europe, a sweltering heatwave contributed to record-breaking temperatures in many locations and had disastrous consequences on the agricultural sector. These extreme events tend to enhance climate change awareness, but they are only one facet of a sweeping phenomenon. In fact, climate change is likely to have distinct consequences on discrete and continuous climate parameters: on the one hand causing shifts in average temperature and precipitation conditions, and on the other modifying the intensity, frequency, and distribution of extreme events.

The European agricultural sector is expected to be increasingly exposed and vulnerable to the intensifying occurrence and severity of extreme events under climate change. Indeed, compared to changes in the average temperature and precipitation, which may cause a negative long-term response in yields, climate extremes entail specific risks for the agriculture sector: higher interannual variability of yield, higher risk of simultaneous yield failure, and supply chain disruptions subsequently leading to market disruptions.

This study aims to provide the European Parliament with an overview of the challenges faced by the agricultural sector regarding the evolution of climate extreme events in the EU. The study also presents existing solutions to help farmers reduce the effects of extreme weather events and recover from climate disasters. It finally analyses policies supporting these solutions, in particular instruments deployed by Member States in their CAP Strategic Plans (CSP), to be implemented under the new CAP programming (2022-2027).

This study first reviews and summarizes evidence on past and upcoming physical and socio-economic impacts of extreme climate events on EU's agricultural sector (chapter 2). The study then reviews existing solutions for the agricultural sector to better prevent, cope with and recover from adverse climate events with the aim of ensuring the long-term resilience of the sector (chapter 3). Next, it focuses on analysing existing EU policy instruments which have potential to support the sector in managing the adverse effects of climate change (chapter 4). To this end, the chapter analyses CAP Strategic Plans (CSP) validated by the European Commission in late 2022 to understand how Member States plan to support climate change adaptation, in light of intensifying climate extreme events. Chapter 5 summarizes the main findings of the study regarding the remaining challenges for European policies, especially the CAP, in supporting the resilience of the agricultural sector to the adverse effects of climate change. Case studies showcasing relevant approaches to address the major challenges for effectively managing the impacts of extreme climate events are presented. Finally, the main conclusions and recommendations to the European Parliament are provided.

2. EXISTING SCIENTIFIC EVIDENCE ON PAST AND UPCOMING PHYSICAL AND SOCIO-ECONOMIC IMPACTS THROUGH EXTREME CLIMATE EVENTS ON EU'S AGRICULTURAL SECTOR

KEY FINDINGS

- Climate extremes are increasing across Europe with pronounced regional differences, following established trends for the recent past.
- Northern Europe and mountainous regions will likely see more heavy precipitation extremes, while Southern Europe will be faced with severe drought and temperature extremes. Central Europe will endure both heat extremes and an increase in heavy precipitation.
- Drought and heat have caused by far the largest share of negative economic impacts to European agriculture and this is expected to continue into the future.
- Productions vulnerable to climate extremes include maize (heat), tubers (flooding), soybean (high yield variability). Most crops will suffer heavy yield damage in case of drought, so the extent of good soil management, crop selection and water management, in particular natural and artificial water retention and irrigation practices, is a major factor in future vulnerability. Grassland is susceptible to drought, causing cascading impacts on the livestock sector.

2.1. Overview of observed and forecasted adverse extreme weather events

2.1.1. Definition of weather and climate extremes

An extreme weather event is defined as 'an event that is rare at a particular place and time of year' (Seneviratne 2021) [2]. When a pattern of extreme *weather* persists for some time, it can be classified as an extreme climate event.

By definition, then, the characteristics of what is considered an extreme weather or climate event varies from one place to another. Typically, phenomena such as heatwaves, cold spells, heavy rains, storm surges; flooding, landslides, droughts, wildfires and intense storms (wind, hail) can be termed extreme events. When such phenomena occur simultaneously, they are referred to as compound events. Extreme events can have harmful or deadly consequences where human lives and activities are exposed. A glossary of extreme events is provided in the Annex.

[2] Rarity is not a fixed parameter, but events situated below the 10th or above the 90th percentile on a probability density function can be considered rare.

2.1.2. Detection and attribution

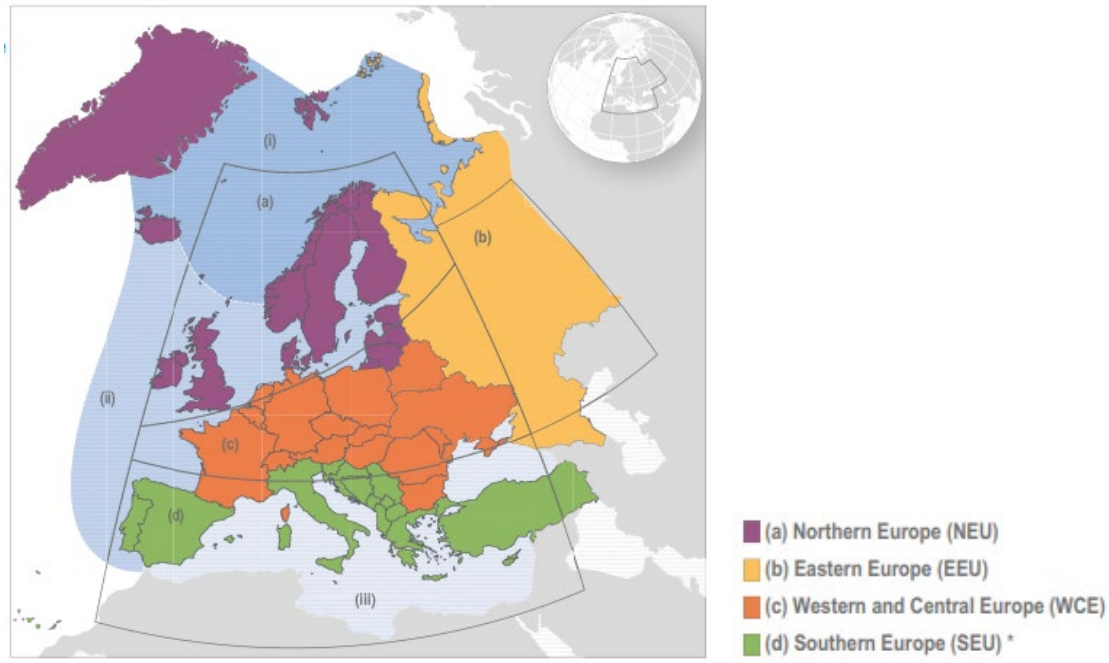
The detection of extreme weather and climate events related to agriculture is based on the detection of changes in agroclimatic conditions (especially daily temperatures, rainfall accumulation, soil moisture/evapotranspiration and wind speed) relative to the baseline climatology[3]. Extreme events take place regardless of climate change. However, climate change may influence the frequency and severity of extreme events. The process of understanding the relative contribution of climate change to extreme events is called "attribution". This is done by comparing the probability of extreme events occurring over time. Attribution studies are carried out using time-series of observed climate over a long period of time (the longer the data period, the more robust the attribution).

The role of climate change on heatwaves is particularly well established: 93% of all heatwave events recorded since 2000 can be attributed to climate change, meaning climate change played a role in their occurrence (Carbon Brief 2022). The record-breaking summer temperatures in 2021 is a notable example. Droughts, however, are more difficult to evaluate in terms of climate change attribution. Only 68% can be attributed to climate change. This is mostly due to the multi-causal nature of droughts (meteorological, hydrological and societal factors).

2.1.3. Historical and observed trends across the EU

The recent trends in terms of extreme weather and climate events across Europe are summarized in the IPCC's AR6 (Seneviratne 2021). The climate model boundaries and a combination of environmental, climatic and non-climatic factors constrain the geographical subdivisions, which are ordered into three areas: Northern Europe (NEU), Western and Central Europe (WCE), and Southern Europe (SEU)[4]. The map showing which countries belong to each category can be found below.

Figure 1: Map displaying the extent of the sub-regions referred to in the IPCC Global Atlas



Source: (Seneviratne 2021)

[3] Climatology is the thirty-year average for each variable.
[4] The area defined as Eastern Europe applies to Russia, which is not considered here as it is outside the EU.

Extremely hot **temperatures** have been attained with increasing regularity throughout Europe since 1950. The continent is indeed becoming a heatwave hotspot (Rousi et al. 2022): with the exception of 2016, summer heatwaves have occurred annually since 2015.

The frequency of **heavy precipitation extremes** has increased in Northern Europe (NEU) and Western and Central Europe (WCE). In the Mediterranean basin, heavy precipitation has not appeared to change, while low precipitation extremes have become more common (Christidis et Stott 2022). Indeed, agricultural **droughts** have increased overall in WCE and SEU but decreased slightly in NEU. Multiyear droughts such as the one that occurred during 2014-2018 in Central Europe are particularly detrimental to ecosystems and agriculture (Moravec et al. 2021). In parallel, a substantial increase in the frequency and spatial extent of flash droughts[5] during the crop growing season has been observed in Central and Southern Europe (Shah et al. 2022).

Trends are computed over thirty-year averages, and a single occurrence should not be mistaken for evidence of a trend. Nonetheless, many recent events fit with the above stated trends in precipitation and temperatures and exemplify how future conditions may grow harsher for agriculture. For instance, the 2022 growing season again saw a severe agricultural drought, combined with high temperatures. Heatwaves were recorded in WCE in 2015, 2017, 2019, 2020, 2021, and 2022. Extreme rainfall and floods on a large scale occur more sporadically, with major events in 2010, 2016, and again in 2021.

2.1.4. Projected trends in extreme weather across the EU

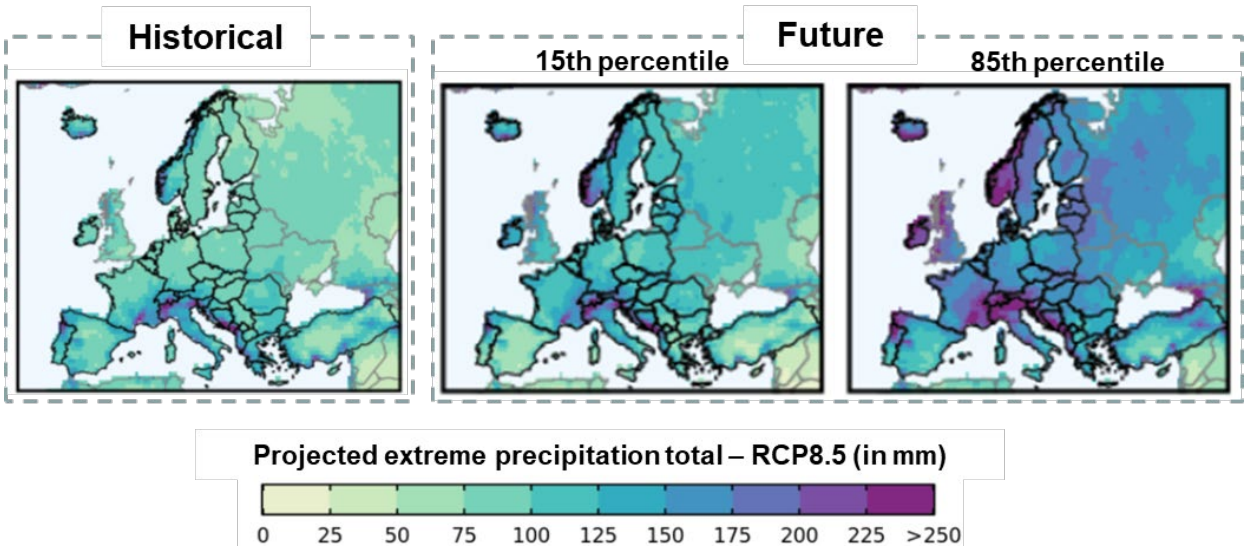
a. Projected changes to key climate parameters

Through climate modelling, it is possible to understand what the future trends for extreme climate events could be. To make accurate use of climate modelling outputs, it is important to compare past ("historical") data with projected ("future") data. Projected data is comprised of a large number of modelling runs under different emission scenarios (RCPs) and using several different models (an pag 16

8.5) and is presented through two maps representing the low end (15th percentile) and high end (85th percentile) of the possible outcomes. RCP 8.5 is typically used for two reasons. First, it clearly shows the direction of climate trends. Second, it is most consistent with cumulative CO2 emissions (Schwalm, Glendon, et Duffy 2020).

[5] Flash drought is a type of extreme event characterized by rapid intensification of drought/dryness conditions, unlike conventional droughts. Flash droughts are mostly short-duration, intense drought events causing multifaceted impacts on water resources, agriculture, and ecosystem. Unlike conventional droughts (i.e., slow- developing droughts), which are mainly attributed to the decline in precipitation, the onset of flash droughts occurs when low precipitation is accompanied by abnormally high temperature, high winds and/or change in atmospheric radiation.

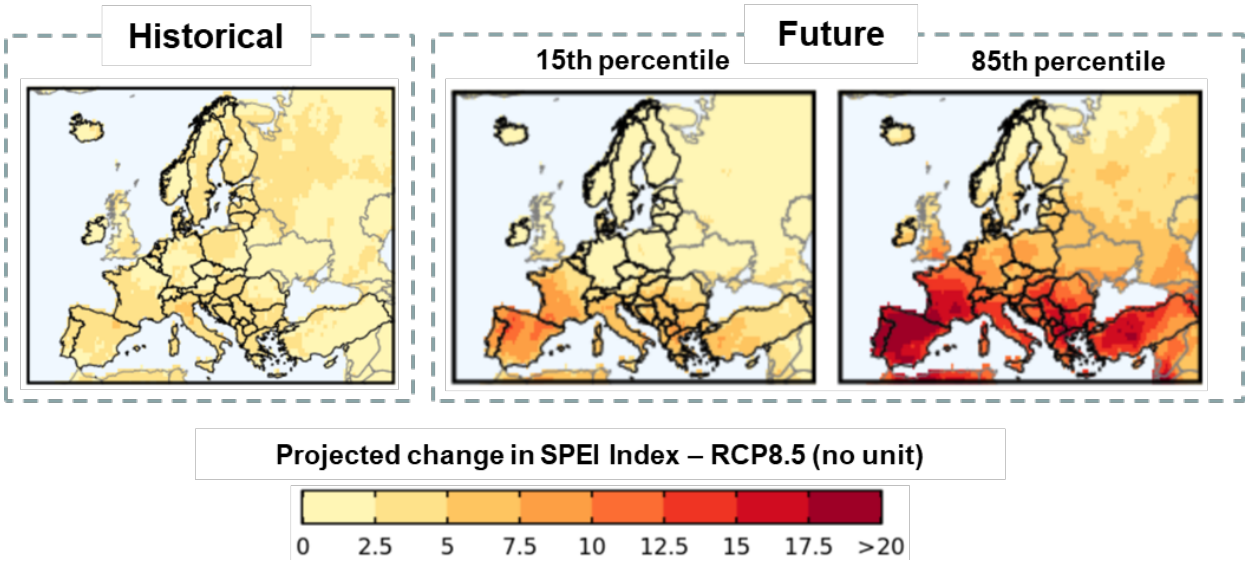
Figure 2: **Projected changes in extreme precipitation across Europe: historical (left), and for the end of the century (RCP8.5): 15th percentile (middle) and 85th percentile (right)**



Source: (EEA 2022d)

Extreme precipitation totals (cumulative precipitation received on days where precipitation exceeds the 99th percentile, in millimeters) is a useful indicator as it accounts for both the frequency and magnitude of extreme precipitation events. These are expected to increase broadly across Europe, prolonging trends in the distribution of current extremes. Totals could surpass 250mm in much of the Alps, in Norway and the North of Spain. Where a broad swath of Europe previously saw no more than 100mm of extreme precipitation, the high range of projections show that 150mm will become the norm.

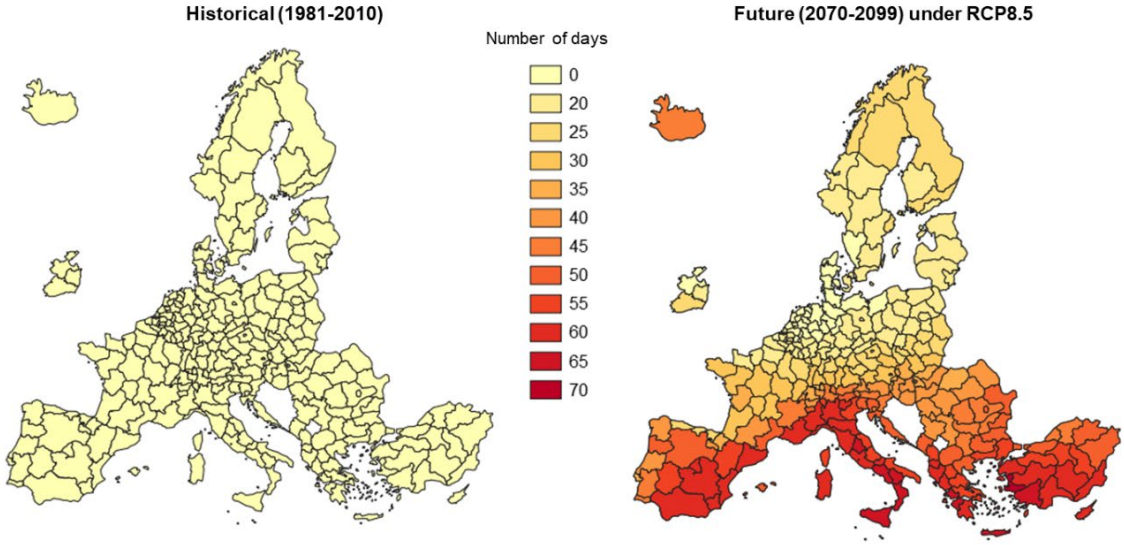
Figure 3: **Projected changes in drought magnitude across Europe: historical (left), and for the end of the century (RCP8.5): 15th percentile (middle) and 85th percentile (right)**



Source: (EEA 2022c)

The drought magnitude index (SPEI[6]) shows a slight decrease in Northern Europe in future trends, but a marked increase across much of central Europe and a tripling in magnitude across the whole of Southern Europe. Such an increase in the intensity of meteorological droughts could have catastrophic repercussions on agricultural systems in large parts of Europe.

Figure 4: Increase in the number of apparent heatwave days compared to the reference period (left) by the end of the century (RCP 8.5, right)



Source: (Authors, based on EEA 2022a)

An increase in the number of heatwave days is projected over all of Europe, with significant variation depending on latitude. The increase is most pronounced in the Mediterranean border regions, the North of Italy, and central Spain, where the number of heatwave days could increase thirtyfold compared to the 1971 – 2000 reference period.

b. Summary of trends at European level

Major trends for the European sub-regions, as presented in the IPCC's Regional Atlas, are the following:

- **Extreme temperatures and heat indices** are projected to increase across all of Europe. For instance, a heatwave that occurred every 10 years in the pre-industrial period will now occur every 3.5 years, and in the future will occur every 1.8 years. A heatwave that occurred every 50 years in the pre-industrial period will now take place every 10 years, and every 3 to 4 years in future. The peak temperature reached during these heatwave events will also increase by 2.6°C.
- **Agricultural droughts** are projected to increase in WCE and SEU but decrease in NEU. However, flash droughts are projected to increase across Europe, which is projected to become a flash drought hotspot.
- **Compound events of hot and dry** will be particularly prevalent in the SEU region. Warming is particularly strong for winter temperatures in NEU and for summer temperatures in SEU region. Very hot days are projected to increase in the central-southern areas of the Iberian Peninsula.
- **Frost and cold spell events** will generally decrease across Europe.
- **Heavy precipitation** will generally increase across Europe, though confidence in projections remain weak for MED region.

[6] Standardized Precipitation and Evapotranspiration Index – commonly used index for drought

Table 1: Summary of past and projected changes in extreme event occurrence over Europe

Type of extreme event	Observed changes in extreme events in past years			Projected future evolutions with 2°C warming		
Region	**SEU**	**WCE**	**NEU**	**SEU**	**WCE**	**NEU**
Hail	∴			∴		
Heavy rainfall	·	▲	▲	○	▲	▲
Frost	∴			∴		
Heatwaves	▲	▲	▲	▲	▲	▲
Droughts	▲	▲	▽	▲	▲	▽
Cold spell	▽	▽	▽	▽	▽	▽

Legend:

Increase / Decrease			Uncertain direction of outcome	No change expected	No data
Medium likelihood	Very likely	Extremely likely or virtually certain	·	○	∴
▲/▽	▲/▽	▲/▽			

Source: Authors

2.2. Impacts of extreme climate events on agriculture production in Europe

2.2.1. Linking extreme events to agricultural production

Agriculture is particularly sensitive to variation in weather, especially temperature and rainfall patterns, and is therefore vulnerable to extreme climate events. They can harm agricultural production by causing physical damage to harvest or livestock. The impact of past extreme events is usually measured in yield losses translated to economics losses (see section 2.2.2), using datasets such as crop yield from FAO and/or disaster monitoring data. Assessing the impact of future extreme events is complex and relies on various modelling approaches: chiefly empirical (e.g., statistical regression), process-based (crop yield estimates) and integrated (cost estimates) modelling approaches. It is important to note that in most studies projecting future yield, the effects of extreme weather conditions are oversimplified. For example, extreme high temperatures and/or precipitation events occurring at crop anthesis can considerably reduce grain/fruit formation and impede flowering. The accuracy of impact projections also depends on the accuracy of projected climate data and how well they capture future extremes. This means that many studies may actually underestimate the future impacts of climate change on crop productivity, especially in Europe where the impacts of extreme events are expected to be quite high (Van Oort et al. 2012).

Box 1: Approaches for modelling impacts of extreme events

Empirical modelling approaches are based on crop-climate statistics, or agroecological zone indicators derived from climate and soil information combined with simple soil water budget estimates. These approaches are useful to assess large scale trends in crop-climate relationships but cannot capture non-linear responses and tipping-points. In addition, representation of farming management practices is limited in these approaches (Bezner Kerr et al. 2022; Deryng et al. 2014) .

Process-based modelling approaches represent detailed biophysical processes and are more suited to capture the effect of diverse farming management practices. They require substantial amount of data for parameterisation and calibration. Progresses in the development of agricultural dataset have enabled these approaches to produce large-scale projections of climate change impacts on crop yields. Yet some factors remain overlooked and require further research and development such as the effect of elevated CO^2 on crop quality and the interaction between extreme weather conditions and elevated CO_2 on crop development (Bezner Kerr et al. 2022).

Integrated modelling approaches integrate economic drivers and climate change effects on agriculture to estimate economic costs of climate change impacts as well as cost of climate actions (historically focusing primarily on mitigation measures but increasingly incorporating adaptation measures) (Bezner Kerr et al. 2022). (Yet these approaches may oversimplify agricultural processes and uncertainties cascade across the climate-crop-economic modelling modules (Nelson et al. 2014). Interestingly, some recent development in impacts assessments are able to consider multiple components of food systems to include mixed farming systems representing animals, crops and tree interactions (Bezner Kerr et al. 2022; Mbow et al. 2019)).

Using statistical methods and modelling, researchers have explored how and to what extent each type of climate extreme affects agricultural production. Hot and dry conditions emerge as the most damaging to crops, as opposed to wet conditions (Lesk, Rowhani, et Ramankutty 2016) (Brás et al. 2021). Some researchers argue that heat stress by itself does not affect agricultural productivity more than average climate change (Fabri, Moretti, et Passel 2022). (Orth et al. 2022) confirm that drought contributes the major share of the compound drought – heat impact. Additionally, this study based on historical analysis shows that storms do not have an important impact -contrary to flooding, drought, frost, and heatwaves, and insists on the spatial differences across Europe. For instance, (van Tilburg et Hudson 2022) and (Diogo et al. 2017)project that in the Netherlands, the strongest impacts will come from extreme temperature rather than drought, which corresponds with findings at global level (Vogel et al. 2019).

Table 2: Mechanisms of impact of different extreme events on agriculture

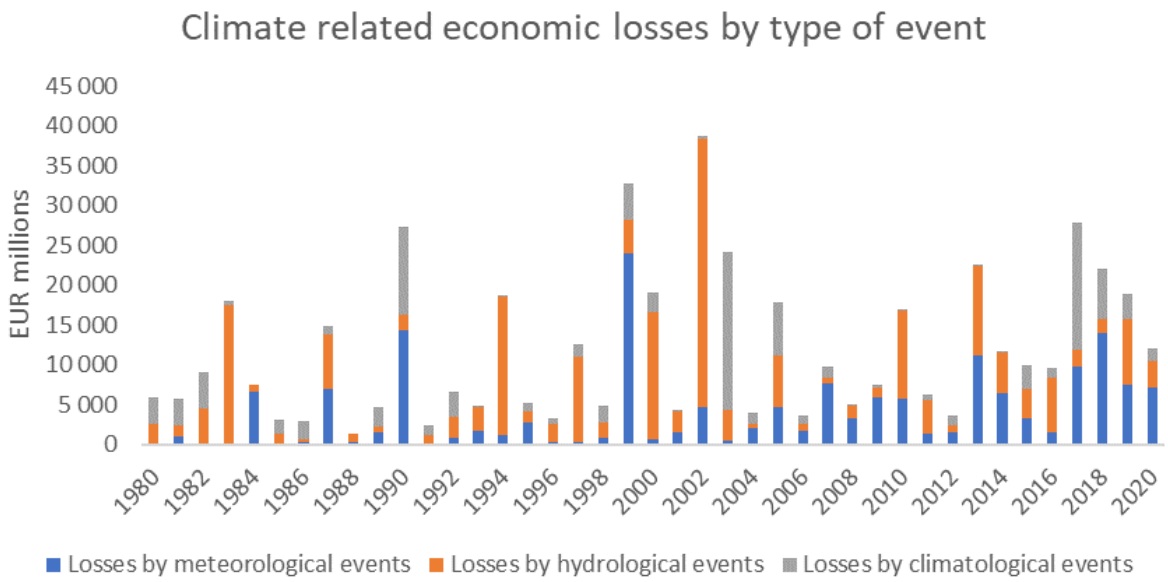
Type of event	How does it affect agriculture?	Cumulative impact
Weather and climate extremes		
Hail	Physical damage to crops; specially damaging to perennials (orchards and vineyards).	Low
Flood/ heavy rainfall	Damages cultivated soils and roots, can delay planting and indirectly reduce crop yields. Extreme wet events have reduced tuber crop yields (potato, sugar beet, onion) in the Netherlands in 1998 and 2018 (van Oort et al. 2023) .	"Waterlogging is less relevant from an economic point of view" (Schmitt et al. 2022)
Frost	Perennials (grapevines, fruit trees such as almonds, pistachios, cherries, apricots, apples) are sensitive both to reduction in winter chill (vernalization requirements for exiting dormancy may not be met) and to late spring frosts, which may freeze buds and curtail harvests (Lamichhane 2021). Most crops (soybean, maize, wheat, potato) benefit from a reduction in frost episodes (van Tilburg et Hudson 2022)	Important economic losses due to value of grapes
Heatwaves	Heat stress affects crop growth. When extreme temperature occurs around flowering time (called anthesis), it can lead to sterilisation (no grain formation) and yield losses. For livestock, heatwaves combined with humid conditions affect reproductive and dairy production capacities and can lead to excess mortality. (Senapati, Halford, et Semenov 2021) find that heat stress around flowering is a minor stress factor under current conditions becoming major under climate change.	High
Droughts (agricultural, meteorological and hydrological)	Agricultural drought, defined based on soil moisture during agriculture growing period, is detrimental to crop growth and can lead to yield reduction and losses. Hydrological droughts reduce water resources for irrigation, impacting adaptive capacity of irrigated cropping systems. Drought stress around flowering is already an important stress factors and will increase with climate change (Senapati, Halford, et Semenov 2021).	High
Cold spell	Can disrupt agriculture indirectly, by disrupting transport of food.	Low
Compound events		
Compound dry	The combination of multiple stresses can intensify the effects on crop growth and lead to new risks. A period of drought combined with extreme temperatures can shrivel crops and lead to fire weather conditions, threatening cropland due to risk of burning of vegetation/crops. Statistical regression shows important losses for winter wheat in Germany, wheat and barley in Spain.	High
Compound wet	The combination of heavy rainfall and strong winds create storm conditions that can destroy cropland, damage soils and provoke landslides.	Low

Source: Authors

2.2.2. Economic impacts

Economic losses are the primary indicator for comparing the impacts of extreme events. Extreme weather events have caused damages reaching nearly €487 billion to EU economies since 1980 (EEA 2022a). This plainly show both the high interannual variability of extreme events and their impacts, and a steady increase in the thirty-year rolling average since 2008 (see 5).

Figure 5: Total losses caused by weather and climate-related extreme events in the EU Member States



Source: (Eurostat 2022a)

Regarding the agriculture sector specifically, (Naumann et al. 2021) estimated that agriculture losses account for more than 50% of total drought losses in Europe, with the highest sector share in the Mediterranean region (60%) and the lowest in the boreal region (39%). Importantly, 3% of extreme events are responsible for 60% of the economic losses.

A global-level assessment of the economic impact of drought on staple crop production (Kim, Iizumi, et Nishimori 2019) finds that the cumulative production losses between 1983 and 2009 related to droughts surpass 150 billion worldwide, with 75% of the world's arable area affected at some point. France (US$6 billion), Italy (US$3 billion), Romania (US$2.5 billion), Spain (US$2 billion), Hungary (US$1 billion), and Poland (US$1 billion) are among the top-25 countries enduring related economic losses. Annual revenue losses are estimated at €23 million in Germany owing to drought (Schmitt et al. 2022).

A striking recent example is the 2003 summer drought and heatwave which lasted from June to mid-August and raised temperature between 3 to 5°C in many parts of Europe. Very high temperatures caused an increase in crop water consumption and depleted soil water availability, causing widespread yield damage. The main affected sectors were green fodder (grazing land), livestock sector, cereals, potato and wine production, and forestry. Fodder deficit was up to 60% in France, and cereals registered a 23-million-ton dip in production from the previous year. The financial cost for France alone was estimated at €4 billion, including €1.5 billion in the beef sector (Olesen et Bindi 2004) - compared to total output of around €25 billion in the overall national husbandry sector. Italy suffered financial

damages of around €4 to 5 billion, and Germany €1.5 billion. Overall, the heatwave caused €13 billion in uninsured losses[7] in the EU.

In terms of future economic damage, analyses performed using Integrated Assessment Modelling show staggering increases. In one study, historical damage from heatwaves reached 0.3 – 0.5% of European GDP, projected to increase fivefold by 2060 (García-León et al. 2021). The economic cost of drought for Europe's agriculture sector stood at around €4.8 billion annually in 2015 and might reach €28.6 billion by 2100 under pessimistic scenarios (Naumann et al. 2021).

2.2.3. Impacts on food security

Food security is usually described through four pillars: availability, access, utilisation, and stability. Extreme climate events can detrimentally affect each of these pillars, as shown in Table 3 .

Table 3: Impacts of extreme events on the pillars of food security

Availability	Access	Utilisation	Stability
Extreme heat and drought **reduce crop and animal productivity**; heatwave (combined with high humidity) reduces agricultural labour capacity (farm outputs) and animal productivity, affecting total output.	Increased drought and flood events without subsidies can lead to loss of agricultural income due to reduced yields, and higher costs of production inputs such as water and fertilizer, leading to **higher food prices**	Climate change extreme events make **fruits and vegetables relatively unaffordable** compared with less-nutrient-dense foods.	Increased frequency and severity of extreme events (e.g., droughts and heatwaves) lead to **greater instability of supply** through production losses and disruption to food transport.
Increasing temperatures and drought stress has led to **higher post-harvest losses** due to mycotoxins	Extreme events (e.g., floods) **disrupt food storage and transport networks**, reducing access and availability of food supplies.	Increased food prices often lead to **lower dietary diversity** as well as **lower consumption levels**.	Increased drought and flood events and increased pests and disease from rising temperatures can cause **widespread and simultaneous crop failure.**
Extreme events such as cyclones lead to **reduced food production** from crop damage and increased pest incidence.			**Price shocks** may become more frequent and price variability increase due to climate change extremes.
Extreme heat and drought **reduce crop and animal productivity**; heatwave (combined with high humidity) reduces agricultural labour capacity (farm outputs) and animal productivity, affecting total output.	Increased drought and flood events without subsidies can lead to loss of agricultural income due to reduced yields, and higher costs of production inputs such as water and fertilizer, leading to **higher food prices**	Climate change extreme events make **fruits and vegetables relatively unaffordable** compared with less-nutrient-dense foods.	Increased frequency and severity of extreme events (e.g., droughts and heatwaves) lead to **greater instability of supply** through production losses and disruption to food transport.

[7] Losses that are not covered under any insurance policy

Availability	Access	Utilisation	Stability
Increasing temperatures and drought stress has led to **higher post-harvest losses** due to mycotoxins	Extreme events (e.g., floods) **disrupt food storage and transport networks**, reducing access and availability of food supplies.	Increased food prices often lead to **lower dietary diversity** as well as **lower consumption levels**.	Increased drought and flood events and increased pests and disease from rising temperatures can cause **widespread and simultaneous crop failure.**
Extreme events such as cyclones lead to **reduced food production** from crop damage and increased pest incidence.			**Price shocks** may become more frequent and price variability increase due to climate change extremes.

Source: Authors

However, in an interconnected world where agricultural commodity markets are globalized and volatile, the risk of food insecurity depends on economic rather than climatic factors. The EU is not specifically exposed to risks of food insecurity, being one of the top producers and traders of agri-food products worldwide. In 2021, extra-EU trade in agricultural products had a surplus of €47 billion (Eurostat 2022b). Yet "selective" food insecurity can be triggered by exceptionally low stocks, contributing to high commodity prices. Affordability then becomes an issue and part of Europe's population may be subject to food insecurity. Though climate change alone presents low risk of food insecurity in Europe, the combination of events such as war and pandemic situations can fragilize the European food systems, making it more vulnerable to climatic shocks. For instance, food prices have risen by 60% since the start of the Ukraine crisis (Consilium 2023).

2.2.4. Impacts on the environment

Extreme weather events impact agricultural soils and ecosystem services essential to agriculture such as freshwater provision and pollination (Bezner Kerr et al. 2022). Extreme precipitations can reduce soil biological functions, and increase surface flooding, waterlogging, soil erosion and susceptibility to salinisation. Prolongated droughts cause vegetation mortality and reduce river flows, impacting freshwater resources for agriculture (European Environment Agency 2017). Finally, pollinators are affected by extreme climatic conditions. Extreme heat could exceed species tolerance thresholds, with subsequent reduction in populations and potential extirpation. Shift in the timing of flowering could also affect pollinator activities.

2.2.5. Uncertainties and limitations

Uncertainties span input data and modelling assumptions and cascade across scales and systems (climatic, crop, livestock, farm). Impact assessments accounting for the impacts of extreme weather events on pollinators and their related impacts on crops are limited. Yield responses to heat and drought appear to be systematically underestimated (Heinicke et al. 2022). Only a limited number of crop model capture the effect of extreme heat stress at anthesis.

2.3. Effects of extreme climate events on key agricultural sub-sectors

Some categories of crops are more severely affected by extreme events. We focus here on a selection of crops that are selected according to their importance in terms of trade value and/or food security: cereals (maize/wheat), soybean, olive trees, grapevines, fruits, grasslands (as a source of green fodder) and livestock. When assessing the vulnerability of a specific crop to extreme events, several factors should be looked at in combination. On one hand, the physiological impact of weather extremes on these crops; on the other, the evidence of yield loss or economic impacts relative to extreme events, which is hindered by a paucity of data. Therefore, an interesting proxy is the year-to-year variability of yields, which is intrinsically linked to climate variability, though not necessarily to extreme events.

Table 4: Impacts of extreme events on various agricultural commodities

Category of crop	Climate/extreme weather susceptibility	Yield variability factor	Evidence of past losses / Estimations of future losses
Maize, wheat, barley	Vulnerable to extreme heat stress & droughts	Yield variability is smaller than price variability	- US$15 billion between 1983 and 2009 due to drought - Climatic suitability for maize diminishing in Southern Europe, but range expansion Northwards (into Denmark for instance) - Climatic suitability for soy expanding westwards
Soybean and other oil crops	Vulnerable to extreme heat stress & droughts	High yield variability	
Tuber crops (potato, onion, sugar beet)	Sensitive to extreme wet conditions during the harvesting period	*No data*	- The 1998 extremely wet harvesting period that occurred in the Netherlands had a major negative impact on onions, potatoes, and sugar beet (van Oort et al. 2023) - Extremes events are found to counterbalance the positive effects of gradual climate change in the Netherlands: wet fields in spring and autumn delay planting and harvesting and cause damage to potato tubers and onions, and in the future heat waves, warm winters, and wet periods could have large impacts (yield losses ranging from -36% to -88%) (Reidsma et al. 2015)
Olive trees	Extremely resilient but some varieties are more vulnerable to agricultural droughts	*No data*	- Late spring frosts and autumn storms can damage olive oil production, such as in Spain in 2021, France in 2019, Greece in 2020 (Olive Oil Times 2022; Sontag 2021) - Serious risks from wildfires - Aptitude to withstand diminishing water availability and warmer summers depends on the variety
Grapevines	Vulnerable to late spring frost	Yield not a relevant factor because subject to specific product quality considerations	- Projected changes in average climate show suitability zones migrating northwards - Recurring late spring frosts which overlap with advanced spring plant phenology are causing heavy losses to the wine industry: nearly €2 billion in 2021, more localized losses in 2017 and 2019 (Ornon 2022; Thomas 2022)
Fruit orchards	Vulnerable to late spring frost, extreme heat and droughts	*No data*	- Recurring late spring frosts overlap with advanced spring plant phenology (early budburst), leading to heavy losses: €3.3 billion in 2017 for the fruit and vine industry (Munich Re 2018)

Category of crop	Climate/extreme weather susceptibility	Yield variability factor	Evidence of past losses / Estimations of future losses
Grasslands	Vulnerable to heat stress and drought	*No data*	- Strong impact of prolonged drought and heatwave on green fodder in 2003 and likely from 2022 episode (Olesen et Bindi 2004) - Average climate change expected to increase productivity, though
Livestock	Vulnerable to extreme heat stress	For milk, low variability due to controlled practices	- €1.5 billion in France alone in 2003 heatwave; heavy losses expected from 2022 drought (Olesen et Bindi 2004)

Source: Authors

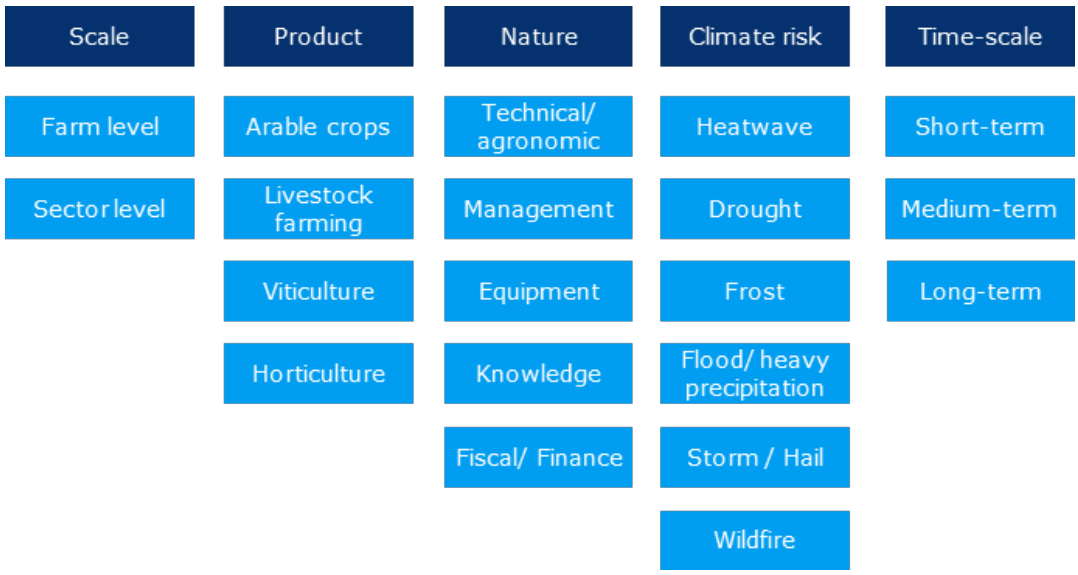
3. AVAILABLE SOLUTIONS FOR THE AGRICULTURE SECTOR TO INCREASE ITS ADAPTIVE CAPACITY AS REGARDS ADVERSE CLIMATE EVENTS AND MAKE AGRICULTURE MORE CLIMATE-RESILIENT

KEY FINDINGS

- The full range of adaptation options is comprised of both top-down measures, mostly involving knowledge production and risk management tools, and autonomous adaptation measures implemented at farm scale.
- Top-down adaptation supported by public or private entities include: climate change observatories, early warning systems; and providing or enhancing access to risk management tools such as insurance, hedging, risk pooling, or mutual funds.
- Autonomous adaptation aims to increase resilience, to protect assets, or stabilize income. On-farm adaptation measures are often combined for greater efficiency, and they may induce trade offs in terms of productivity or environmental impacts (resource usage, emissions to water or soil).

There are many solutions available for the sector to increase its adaptive capacity as regards adverse climate events and make agriculture more climate-resilient (European Commission 2017). While no definitive typology of adaptation options exists, several classifications are possible based on the scale at which they are managed or implemented, the type of product they can be applied to, the nature of the option, the climate risk addressed, and the time scale necessary for its implementation – among others. Figure 6 lays out a typology for each of these parameters.

Figure 6: Descriptive parameters for adaptation options in the agriculture sector



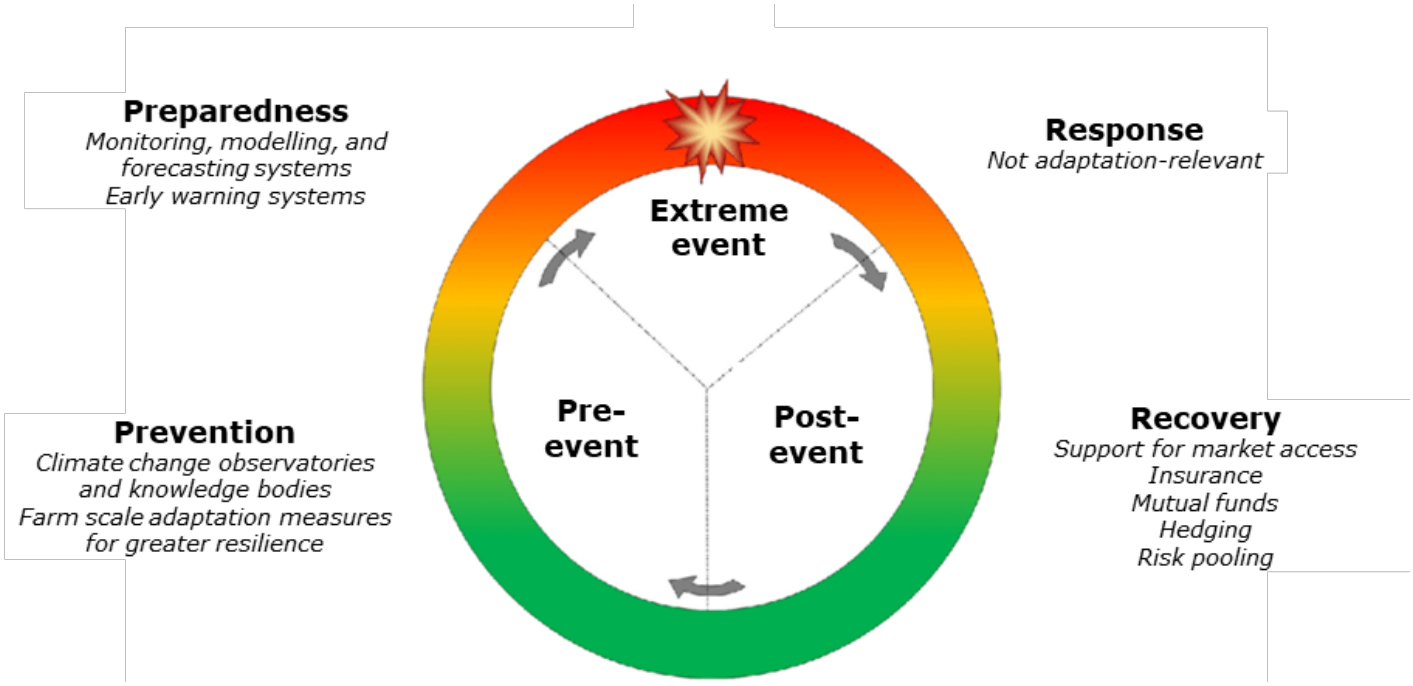
Source: Authors

Depending on the *scale* of the adaptation options considered, responsibility for implementing them rests with different actors. A raft of options can be implemented with a top-down approach, i.e., by the authorities or by organizations at the sub-sectoral level, in order to shield the sector from extreme climate extreme hazards or restore stability after an extreme event. This consists mostly of risk management tools and knowledge dissemination [see 3.1]. Another set of adaptation options can be deployed at farm-level by farmers themselves, whether relative to agronomy, equipment, or changes in land management. [see 3.2]. The manner in which these adaptation options can be incentivized through policy instruments is addressed in sections 3 and 4.

3.1. Adaptation options of the sector as regards agricultural production systems

To describe the timing of the implementation of "top-down" adaptation options, the disaster risk management cycle is a useful parallel (see Figure 7).

Figure 7: Disaster risk management cycle adapted to extreme events in an economic sector



Source: Authors

Some options can be deployed pre-event, i.e., to prevent or reduce the effects of an extreme event through planning or emergency protection measures. Following an extreme event, other types of measures are needed to help restore damaged assets and support financial recovery. The sections that follow provide a description and examples of these different types of adaptation strategies.

3.1.1. Preventing the impacts of extreme events

Observatories and bodies dealing with climate adaptation and climate risk assessment and/or management.

Different types of organisations are set up by Member states and can play a role when it comes to climate risk assessment, risk management and adaptation policies. Though most are not focused on the agriculture sector, they examine the potential impact of climate risks on different sectors and at

how to prevent and prepare the response to these climate disasters (European Environment Agency 2017). In this sense, they are useful platforms for stakeholders seeking data on extreme climate events and their potential impact on agricultural systems. These bodies can be categorized into three different types:

Table 5: Summary of the various types of governmental agencies providing climate knowledge

Type of body	Role	Example
Civil protection or Disaster Risk Management organisations	Deal with risk assessment, risk management, risk prevention and response preparedness for a variety of risks (incl. climate-related risk). Depending on the structure, they manage risk from an operational point of view, or are involved in providing knowledge critical to implementing risk management.	"Traditional" civil protection organisations (every Member State has one Networks or centres of expertise (Natural Hazards Partnership in the UK[8], Center for Research on Risk Reduction in Italy[9]
Coordination or Advisory bodies	Placed at the intersection between political and scientific/expert bodies, that provide advice for decision-making related to climate adaptation; involved in the collection, production, sharing of knowledge to support decision making in the field of climate (adaptation) policy.	PBL in the Netherlands[10], CCC in the UK[11] and The Finnish Climate Change Panel in Finland, National Observatory on the impacts of Climate Change (ONERC)[12] in France
Climate services or Research institutions	They generate, collect, distribute knowledge and information in relations to climate change (incl. climate extreme events), and provide several climate-related services. They may publish studies, reports, case studies or data, and provide recommendations for decision-makers or practitioners on public platforms meant to be easily accessible to the public.	Examples at European scale: Copernicus Climate Data Store[13], the European Environment Agency's CLIMATEADAPT platform[14].

Source: Authors

Research and innovation in the agriculture sector

The agriculture sector (public and private actors, agriculture unions) devotes large amounts of funding to research and innovation in order to develop solutions which might minimize the impacts of climate extreme events on agriculture (Auci et al. 2021). For instance, several research projects focus on how to adapt crop varieties to increase their resilience to a changing climate. The use of adapted crops and varieties is identified as a climate-smart practice for risk reduction, soil and water conservation, and efficient water management. It has the potential to reduce the negative impacts of climate change on agricultural systems whilst ensuring stable agricultural production. Introducing new crops or varieties, or bringing back heritage crops, can lead to diversification of agricultural production, with positive effects on biodiversity and ecosystem services, especially if cultivated in association with conservation agriculture practices (see adaptation solutions available at farm-level in 3.2). In addition, the system's

[8] Available at: https://www.metoffice.gov.uk/services/government/environmental-hazard-resilience/natural-hazards-partnership
[9] Available at: https://www.ci3r.it/en/home-english/
[10] Available at: https://www.pbl.nl/en
[11] Available at: https://www.theccc.org.uk/
[12] Available at: https://www.ecologie.gouv.fr/observatoire-national-sur-effets-du-rechauffement-climatique-onerc
[13] Available at: https://cds.climate.copernicus.eu/#!/home
[14] Available at: https://climate-adapt.eea.europa.eu/

ability to respond to exterior stresses is heightened, reducing the risk of total crop failure. Research and innovation in the agriculture sector is crucial for reducing potential impacts of extreme climate events.

Multiple adaptation options to support resilience and increase prevention and preparedness at farm scale

Adaptation options that can be deployed at farm-level also support prevention and preparedness to climate extreme events. Policy support for these adaptation options is a key route to contributing to better management of extreme events by increasing resilience. Adaptation options at farm-level are described in detail in section 3.2.

3.1.2. Preparing for the impacts of extreme events

Monitoring, modeling, and forecasting systems

Monitoring, modeling, and forecasting systems are essential tools for adapting agriculture systems to the impacts of climate extreme events by increasing preparedness to climate disasters. These systems use a combination of data collection, analysis, and prediction to provide valuable information on weather patterns, soil conditions, and crop growth. By monitoring current conditions and forecasting potential changes, farmers can make informed decisions about irrigation, fertilization, and crop selection. Additionally, modeling allows for the simulation of different scenarios, enabling farmers to test the potential outcomes of different management strategies. These systems are often integrated within existing climate observatories or climate services and research institutions.

The **European Drought Observatory** (EDO)[15], established by the Joint Research Centre, is one such example. EDO was established following the idea that communication, information sharing, and contingency planning can help reduce the impacts of extreme climate events. The EDO provides a comprehensive overview of drought conditions in Europe by combining data from various sources, such as meteorological and hydrological observations, remote sensing, and numerical models. The system provides information on the current and past drought conditions, as well as forecasts of future drought conditions. The observatory provides access to monitoring indicators such as soil moisture, evapotranspiration, vegetation status, and streamflow, early warning for droughts, and impact assessments. It is a decision-making tool for public authorities, stakeholders in the water management and agriculture sectors, and other actors, helping to improve the resilience of European society and the economy to the impacts of drought.

Another example in Europe is the Agri4Cast project[16]. The Agri4Cast project is a collaboration between the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF) that provides detailed weather forecasts and analysis for farmers and other stakeholders in the agricultural sector. The project uses a combination of ground-based weather stations, remote sensing data, and numerical weather prediction models to provide high-resolution forecasts for crop growth, soil moisture, and other factors that are important for agriculture. The forecasts are used to support decision-making by farmers, agricultural advisors, and policymakers, helping to improve the resilience of European agriculture to the impacts of extreme weather events and climate change.

15 Available at: https://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1000
16 Available at: https://agri4cast.jrc.ec.europa.eu/DataPortal/Index.aspx?o=d

Establishment of early warning systems

Early warning systems have the potential to significantly increase the preparedness of the agriculture sector in Europe to climate extreme events. These systems use a combination of monitoring, modeling, and forecasting to provide early warning of imminent extreme weather events, such as heat waves, droughts, and floods. By providing advance notice of these events, early warning systems can help farmers to take proactive measures to protect their crops and livestock and minimize losses.

For example, early warning systems can be used to provide farmers with information about the timing, intensity, and duration of extreme weather events, allowing them to adjust their irrigation and fertilization schedules to minimize the impact on crop growth. They can also be used to provide information about soil moisture and other factors that are important for crop growth, allowing farmers to select the most appropriate crop varieties and management strategies. In the case of droughts, early warning systems can also provide information about water availability, allowing farmers to plan for irrigation and water management. An example is the Worklimate project, which aims to develop an integrated weather, climatic and epidemiological heat health warning system in the agriculture sector in Puglia, southern Italy, thus protecting outdoor agricultural workers from extreme heat[17].

Moreover, in addition to helping farmers to reduce losses, early warning systems can also improve the resilience of the agriculture sector as a whole. By providing advance warning of extreme weather events, early warning systems can help policymakers and other stakeholders such as farmer unions to develop and implement effective adaptation measures to reduce the impacts of climate change on the agriculture sector.

3.1.3. Responding to extreme events

Responses to climate extreme events and disasters mostly fall under the action of civil protection organisations and the provision of disaster assistance to farmer by public authorities and do not represent adaptation solution for the agriculture sector.

3.1.4. Supporting recovery from extreme events

The options falling under recovery strategies mainly aim to provide financial support to farmers in order to help them recover from losses due to severe climate events (e.g., replanting crops, repairing damage to infrastructure) or to help them face the impacts of these climate events (e.g., price fluctuations) (Farm Europe 2016). In this way, recovery solutions also contribute to making the farmers more resilient to future climate extremes.

Support for market access

Support for market access refers to the various programs and initiatives that are put in place to help farmers and rural communities recover from the impacts of severe weather events (Stringer et al. 2020). This can include a variety of different types of assistance, such as:

- Emergency financial assistance: this can include cash payments or low-interest loans to help farmers cover immediate costs associated with recovery, such as the cost of replanting crops or repairing damage to infrastructure.
- Technical assistance: this can include expert guidance on how to replant crops or repair damaged infrastructure, as well as information on how to access other forms of assistance.

[17] Worklimate project. Available at: https://www.worklimate.it/en/the-project/

- Infrastructure support: this refers to funding for the repair or reconstruction of public infrastructure such as roads, bridges, and irrigation systems that were damaged or destroyed by the disaster.
- Market linkages: this option is about connecting farmers with new markets, either by helping them access existing markets or by creating new market opportunities. For example, this can include providing funding for the development of new processing or storage facilities, or supporting the creation of farmer cooperatives that can negotiate better prices for farmers' products. The re-organization of the value chain per agriculture sub-sector combined with support to farmers for accessing new markets for their products is a key element for recovery post-disaster.

Insurance

Crop and livestock insurance can help farmers to financially protect themselves against crop or livestock losses due to weather hazards such as droughts, floods, storms, and other natural disasters (Kraehnert et al. 2021; Vroege et Finger 2020). There are several different types of crop insurance available to farmers, including:

- **Multi-peril crop insurance** (MPCI): this type of insurance covers a wide range of crop-related perils, including weather hazards, pests, and diseases. It is generally available for a wide variety of crops and can be a useful tool for farmers who want to protect themselves against a wide range of risks. In addition, specific crop-hail insurances are available to farmers in most EU countries to cover losses due to hail damage.
- **Index-based insurance:** this type of insurance uses weather data and other indices to trigger payouts to farmers, rather than requiring an individual assessment of damage. This can be more cost-effective and efficient and can be useful for farmers in remote areas where it may be difficult to conduct individual assessments.
- **Revenue insurance:** this type of insurance helps protect farmers against revenue losses due to a variety of factors, including weather hazards, pests, and diseases. It can be useful for farmers who want to protect themselves against price fluctuations in addition to climate hazards.

Mutual funds

Mutual funds are investment funds that pool money from multiple investors to invest in different assets, including agricultural commodities (European Commission 2017). These funds could potentially be helpful in the context of post-climate disaster recovery by providing the farmers with an opportunity to diversify their investments and spread their risk. This is a way to reduce their exposure to the impacts of climate change by modulating their sources of income.

Hedging

Hedging is a financial strategy that involves buying and selling contracts, such as futures contracts, options contracts or forward contracts, to offset the risk of price fluctuations of a commodity (European Commission 2017) .This can help farmers lock in a price for their crops in advance and protect themselves from market volatility following a climate disaster.

Risk pooling

Risk pooling is a risk management strategy that involves farmers joining together to share risks and resources (European Commission 2017). This can include forming cooperatives or joining mutual

insurance schemes, which can reduce the overall cost of insurance and increase the overall level of coverage.

3.2. Solutions available to EU farmers by a set of adaptive strategies

3.2.1. Overview of available measures

At farm level, farmers can deploy a variety of measures to safeguard against the impacts of extreme events. We describe these measures as falling into one of three adaptive strategies:

- **Protect assets** from physical damage / investment can take years but effects are immediate / often consists of "Hard" measures
- **Stabilize income** in the face of climate variability / "Income" measures
- **Increase** farming system **resilience**/ effects often take shape in the long term / usually consists of "Soft" measures

Table 6: List of adaptation practices categorized by adaptive strategies

Adaptive strategy	Adaptation practices	Typology
Protect assets	**Improve irrigation efficiency** by installing drip irrigation, subsurface irrigation, smart irrigation scheduling, connecting irrigation systems to rainwater	Equipment / Management
	Increase shelter for animals to protect against elements and heat	Equipment
	Install ecosystem compatible drainage	Technical
	Intercept rainfall to increase water availability, using small-scale reservoirs or other methods to collect rainwater (fog nets)	Technical
	Enhance flood plain management to reduce flood damage, by breaching/removing or setting back embankments, and allowing for flood expansion areas on agricultural land -entails converting agricultural land to prairies.	Management
	Landscape design using hedgerows, buffers, tree shelters to protect crops and or livestock (for instance, protect crops from strong winds).	Management
	Active protection against frost (through use of heaters or candles, sprinklers and wind machines)	Equipment
	Shade and nylon hail protection nets for orchards	Equipment
	Use of greenhouses to protect vegetables: for controlled climate and to augment protection against storm damage.	Equipment
	Use of precision farming to determine best timing for on-field operations: can help avoid soil compaction, optimize growing season length, and prevent yield losses due to late harvesting.	Management
Stabilize income	**Acquire insurance products** for climate and weather risks (see section 2.1)	Financial
	Deploy complex risk management tools, such as futures markets, derivatives, or mutual funds	Financial
	Farm activity and production diversification to offset risk of simultaneous income loss	Management
Increase resilience	**Improve soil health and soil structure to improve water retention and drainage capacity** * *through minimum/ no-tillage practices.* Several practices can help benefit soil health: conservation agriculture, no tillage or minimum tillage, and careful timing of field operations to avoid soil compaction.	Technical

	* *by increasing soil organic matter* using cover crops, diversification of crop rotations, or the addition of organic material (through green fertilizer, organic or inorganic fertilizer).	
	Implement crop diversification and rotation by introducing forage crops into arable rotations, practicing mixed cropping, fallowing arable cropland.	Technical
	Introduce more heat tolerant breeds of livestock to reduce mortality under hot conditions.	Technical
	Change crop varieties to adapt to changing conditions. Heat tolerant crop varieties may be newly developed or traditional, "rustic" varieties. Switching crop varieties may induce changes in crop calendars and water demand.	Technical
	Alternative Wetting and Drying is an alternative rice-growing method when flooded rice plains are not an option; it has mitigation co-benefits as it emits significantly less methane.	Technical
	Plan feed alternatives in case of drought, for instance through the use of feed and fodder banks.	Management
	Improve pasture and grazing management to match stocking densities to forage production and reduce grazing pressures	Management
	Develop agroforestery within silvo-arable or silvo-pastoral systems, providing benefits to biodiversity, soil health, and in some cases physical protection such as shade or wind-breaking.	Technical

Source: Authors

Legend: Primary risk faced	Risk of drought and water scarcity	Flood risk	Risk from frost, hail and storms	Combined risk from extreme weather

3.2.2. Efficiency against climate extremes

Some evidence exists testifying to the efficiency of these practices in supporting productivity in the face of climate or weather extremes. Most of this evidence derives from experimental approaches, which may induce some bias in the study results.

No till or reduced till has been well studied through experimental systems in various regions of Europe. Reduced tillage is found to have positive consequences in terms of soil structure and abundance of soil biota, soil organic carbon storage, and increases in water retention capacity. In most cases, no-till or low-till also reduces yield by around 5% (averaged across multiple crops), at least in the first few years. This is due to stronger weed pressure in the absence of tillage. In dry climates and under climate change conditions, however, such yield gaps may be reversed (Arriaga, Guzman, et Lowery 2017; Cooper et al. 2016). Available evidence on actual changes in crop yields suggests that conservation agriculture (combination of no till, crop rotation, and crop cover) has the greatest potential to increase crop yields when implemented as a set of integrated practices in rainfed systems in water-limited or water-stressed regions (Miralles-Wilhelm 2021).

In the case of **agroforestry**, the association of trees and crops is shown to create a more resilient microclimate for crops or livestock. In Spain, an experiment combining short-cycle cereals and late sprouting walnuts demonstrated that partial shade could offer protection from the more frequently occurring spring heat waves that damage cereal crops in Mediterranean countries (Arenas-Corraliza, López-Díaz, et Moreno 2018). An added benefit is income diversification stemming from sales of fruit or wood products, which also contributes to mitigating risk from extreme weather translating to price shocks. Though the LER[18] ratio is systematically higher than 1 (Sereke et al. 2015), meaning joint

[18] LER = Land Equivalent Ratio: the ratio of the area under sole cropping to the area under intercropping needed to give equal amounts of yield at the same management level.

systems are more productive in terms of biomass growth than separate forestry or arable systems, actual crop yields clearly diminish beyond a certain tree growth threshold (Sollen-Norrlin, Ghaley, et Rintoul 2020).

An example of autonomous adaptation – ie, through impulsion of the farmers themselves – was documented under real conditions using a farmer survey in Zeeland, Netherlands. In the face of a perceived and statistically significant increase in extreme weather and climate events, one-third of farmers have stopped cultivating potatoes and onions. The most common adaptation measures included changing fertilizer usage, sowing more wheat instead of potatoes and onions, and implementing reduced tillage to conserve water in soils. Upfront cost of implementing adaptation solutions emerges as a decisive factor in the selection of such practices (van Tilburg et Hudson 2022).

4. EU POLICY INSTRUMENTS SUPPORTING THE SECTOR TO PRO-ACTIVELY MITIGATE EFFECTS OF EXTREME WEATHER EVENTS CAUSED BY CLIMATE CHANGE

The European Green Deal, approved in 2020, consists of a set of policy initiatives by the European Commission whose overall objective is to make the European Union (EU) climate neutral by 2050, but also to limit the adverse effects of climate change, move towards a clean and circular economy, reverse biodiversity loss and reduce pollution. The European Green Deal thus encompasses a range of policy initiatives (e.g., strategies, action plans), including the Farm to Fork Strategy, the Biodiversity Strategy, and others.

Though not all of these strategies and policy initiatives specifically target the agricultural sector, many nevertheless propose actions or support solutions - notably related to water management and land use - that directly or indirectly impact the agricultural sector's resilience towards climate change.

The Common Agricultural Policy (CAP) remains an essential lever for putting these strategies and policy initiatives into action and helps contribute to the European Green Deal objectives.

This chapter gives an overview of the extent to which the adaptation of the agricultural sector to extreme climate or weather events - exacerbated by climate change - is supported by European policy instruments and integrated into planning documents at Member State level. The list of instruments examined is presented below.

Table 7: EU instruments considered in the analysis

Instruments	Nature of the instrument (EU monitor from Europa Nu. s. d.)		Instruments analysed that have a potential to support the resilience of the agriculture sector
Policies, programmes, strategies (presented through communications)	Non-binding legal instrument	Communications are non-legally binding documents sent by the EC to the other European institutions which present new programmes and policies.	EU Water Scarcity and Droughts Policy (COM(2012) 672)
			Farm to Fork Strategy (COM(2020) 381)
			EU Adaptation Strategy (COM(2021) 82)
			EU Biodiversity Strategy for 2030 (COM(2020) 380)
			EU Soil Strategy for 2030 (COM(2021)699
Directive	Binding legal instrument	Directives establish a set of objectives that all MS are required to fulfil. However, it is up to the individual Member States to devise their own laws on how to reach these goals.	Water Framework Directive 2000/60/EC
			Groundwater Directive 2006/118/EC
			Floods Directive 2007/60/EC
Regulations	Binding legal instrument	Regulations are directly applicable in all MS. The regulation is similar to national legislation in terms of the impact and direct effect it generates. As such the regulation is the most impactful of all the legal instruments of the EU.	LULUCF Regulation for 2021-2030
			European Climate Law Regulation (EU) 2021/1119
			Common Agricultural Policy (CAP), governed by three main regulations: Regulation (EU) 2021/2115, Regulation (EU) 2021/2116, Regulation (EU) 2021/2117.
			EU Nature Restoration Law 2022/0195

Legend

Related sector	Climate	Agriculture	Water	Land use	Biodiversity and food

Source: Authors

4.1. Available policies at EU level (outside the CAP) to contain the adverse effects of climate change for agriculture

KEY FINDINGS

- The large number of European strategies that have been developed in recent years (Farm to Fork Strategy, EU Adaptation Strategy, EU Biodiversity Strategy for 2030, EU Soil Strategy for 2030, etc.) calls for a better coordination between European policies and a systemic approach of environmental and climate issues associated with the agricultural sector in order to achieve the objectives of the Green Deal, while supporting long-term sustainability and resilience of the agricultural sector.
- Management of extreme climate events in the agricultural sector mostly deals with floods and drought. Other extreme events (heatwaves, frost, etc.) are less well addressed.
- There is currently no European directive or regulation specifically dedicated to drought management. Most EU countries nevertheless have –policy frameworks and management processes to tackle drought events. Member States must prepare Drought Management Plans to be presented to the European Commission, even though there is no strict European legal framework on the subject.
- With regards to flood management, the Floods Directive (2007/60/EC) provides the EU with an appropriate legal framework. However, synergies between flood risk management policies and agricultural policies are still limited.

For each sectoral policy instrument, the following table is provided to summarise our analysis concerning the level of integration of climate change adaptation issues within EU instruments (CAP excluded).

Table 8: Analytical matrix providing an overview of the extent to which climate adaptation issues in the agricultural sector are integrated into EU instruments (policies, strategies, directives and regulations; excluding the CAP) and supported by implementation documents at MS level

Are climate change adaptation issues specifically addressed by the EU instruments, related to climate, agriculture, water and land use (non-CAP)?	Do planning documents at MS level (if existing), related to climate, agriculture, water and land use (non-CAP), promote specific climate change adaptation options?		
Yes, directly (i.e., adaptation to climate change is one of the specific objectives of the instrument and is addressed through specific interventions).	Yes, most of the MS promote specific adaptation options within those implementation documents	If so, are the agriculture sector issues, regarding climate change, specifically addressed?	Yes
Yes, indirectly (i.e., adaptation to climate change can be supported by specific interventions of the instrument but is not one of its main objectives).	Progress is being made in mainstreaming adaptation options into those implementation documents		Not sufficiently
No	Not sufficiently		

Source: Authors

4.1.1. Potential of EU water policies and plans to strengthen the resilience of the agricultural sector with regards to climate change, and main gaps identified

Table 9: Potential of EU water policies and plans to strengthen the resilience of the agricultural sector with regards to climate change

Instruments at EU level	Adaptation issues addressed by the policy?	Planning documents at MS level	Adaptation options promoted in the planning documents?	Agri. issues regarding climate change addressed?
EU Water Framework Directive (WFD) 2000/60/EC	Indirectly	River Basin Management Plans (RBMP)	In progress	Not sufficiently
Groundwater Directive 2006/118/EC	Indirectly			
Floods Directive 2007/60/EC	Yes	Flood Risks Management Plans (FRMP)	In progress	Not sufficiently
Communication on water scarcity and droughts COM (2007) 414, supplemented by a 2012 review of the European WS&D Policy (COM(2012) 672)	Yes	Drought Management Plan (DMP)	In progress	Yes

Legend:

Binding instrument	Non-binding instrument

Source: Authors

The Water Framework Directive (WFD) contains several provisions dealing with quantitative aspects of water management. Its primary objective is to achieve good ecological and chemical status of surface waters, and good chemical and quantitative status of groundwater. To achieve good status, Member States are required to tackle hydrological and hydro morphological pressures from e.g. alterations to surface water and groundwater levels from agricultural abstraction, and they must set controls on abstraction such as through water metering of agricultural abstraction. Incentive pricing to support efficient water use is also a key element of the Directive. Most RBMPs include measures to enhance water use efficiency and crop productivity through a switch to more efficient irrigation methods. They also increasingly support the adoption of more drought tolerant crops, dry farming and other soil management practices to enhance soil water retention (EEA 2020). Water storage can also be supported, provided the requirements to reduce its impact on freshwater ecosystems are fulfilled (e.g. requirement to build outside the riverbed, limitations on when the reservoir can be filled) (EEA 2020). Furthermore, in the "CIS guidance document No. 24 River Basin Management in a Changing Climate", Member States agreed that, from the second planning cycle, climate-related threats and adaptation planning should be incorporated into their RBMPs.

Regarding the promotion of concrete adaptation options within the second generation of RBMPs, it has been reported that in only 8 Member States have RBMPs integrating adaptation measures (under KTM24[18]) been identified (BG, DE, FI, FR, IT, RO, SK, HR) (European Commission 2021a). Six of them reported measures contributing to adaptation to climate change for surface water and four of them reported measures contributing to adaptation for groundwater (European Commission 2021c). The total number of MS applying adaptation measures has acutally decreased since 2009 (11 MS with adaptation measures) (European Commission 2021a). Hence, adaptation of water use in the light of climate change should be more largely promoted in the RBMPs, especially in vulnerable Member States.

According to the Floods Directive, all EU Member States must carry out preliminary flood risk assessments (PFRAs) for river basins and coastal zones, in order to prepare flood hazard and risk maps and establish flood risk management plans (FRMPs) focused on prevention, preparedness, and protection (Kapović Solomun et al. 2022). "*Flood risk management plans should be periodically reviewed and if necessary updated, taking into account the likely impacts of climate change on the occurrence of floods*." Furthermore, Member States are encouraged to adopt better environmental options for flood risk management, in particular natural water retention measures on agricultural and forestry land[19]. However, the Floods Directive gives great regulatory discretion to Member States regarding measures for controlling flood risks and does not impose mandatory obligations on Member States. In this respect agriculture can also be included as a key sector contributing to flood risks management, by promoting measures that include for instance more space for rivers, maintenance and/or restoration of floodplains. For the second cycle FRMPs (2016-2021) it has been assessed that the FRMPs of 11 Member States (out of 28) provided strong evidence that climate impacts were considered; those for 15 Member States (out of 28) provided some evidence. The rest showed no evidence. Similarly, it appears that most of the FRMPs do not refer to the national adaptation strategies prepared by Member States under the EU Adaptation Strategy, showing a lack of synergies between national adaptation strategies and FRMPs. In conclusion, FRMPs do not currently sufficiently address climate change and its potential impacts on agriculture.

Finally, the Communication on water scarcity and droughts – which is a guidance rather than legally binding document - promotes key policy areas, such: improvement of water efficiency in agriculture and in urban development; better planning (demand management, land use planning, drought observatory and indicator development); and promotion of adequate implementation instruments, such as financing water efficiency, water pricing and water allocation mechanisms. However, the impact of the Communication on water scarcity and droughts has been assessed as limited so far. Only 7 Member States (Cyprus, Czechia, Greece, Italy, Netherlands, Slovakia, Spain) and the UK reported having drought management plans as documents accompanying all or part of their second RBMPs (2016-2021) (Zal et al. 2021). In 2019, in its report regarding the implementation of the WFD and Groundwater Directive (European Commission 2019), the EC recommended that Member States make greater use of Drought Management Plan (DMP) and better address quantitative water issues and climate change impacts in their third RBMP (2022-2027) that were due for adoption at the end of 2021. The key reason for delays in the implementation of measures tackling water stress has been found to be a lack of secure budgets at Member State level. Similarly, in the EU strategy on adaptation to climate change (COM(2021) 82), adopted in 2021, the European Commission stresses the need for a wider use of Drought Management Plans at national or river basins scale.

To conclude, synergies between water management policies, agricultural policies and climate policies remain limited. Progress needs to be made to strengthen their effective coordination**.** Recommendations were made in 2021 by the European Commission suggesting better integration of flood risk management and drought risk management into CAP strategic plans (Directorate-General for Environment (European Commission) 2021).

[19] www.nwrm.eu

4.1.2. Potential of EU climate policies and plans to strengthen the resilience of the agricultural sector with regards to climate change, and main gaps identified

Table 10: Potential of EU climate policies and plans to strengthen the resilience of the agricultural sector with regards to climate change

Instruments at EU level	Adaptation issues addressed by the policy?	Planning documents at MS level	Adaptation options promoted in the planning documents?	Agri. issues regarding climate change addressed?
European Climate Law Regulation (EU) 2021/1119	Yes	National adaptation strategies and plans	Yes	Yes
EU Adaptation Strategy (COM(2021) 82)	Yes			

Legend:

Binding instrument	Non-binding instrument

Source: Authors

In its Article 5, the Climate Law - which is a legally binding document applicable in all MS - states that *"Member States shall adopt and implement national adaptation strategies and plans, taking into consideration the Union strategy on adaptation to climate change […] and based on robust climate change and vulnerability analyses, progress assessments and indicators, and guided by the best available and most recent scientific evidence."* Among the priority sectors targeted, Member States should address the vulnerability of "*agriculture, and water and food systems, as well as food security, and promote nature-based solutions and ecosystem-based adaptation."* Thus, by September 30th, 2023, and every five years thereafter, the Commission shall assess the collective progress made by all Member States on adaptation and review the consistency of Union measures with ensuring progress on adaptation. Similarly, by 30 September 2023, and every five years thereafter, the Commission intends to assess the consistency of national measures of MS, as set out in their National Adaptation Strategies.

The EU Strategy on Adaptation to Climate Change, published in 2021, aims to make adaptation smarter, faster and more systemic (integrated solutions and plans). Regarding the challenges of the agricultural sector, the following solutions are emphasized:

- **Stimulating local adaptation**, nature-based solutions, sustainable uses and resilience of freshwater resources, that are relevant for the agricultural sector. To this end, financial support through the European Structural and Investment Funds, the Common Agricultural Policy (investments, eco-schemes and advisory services) and the LIFE Programme toward adaptation of the agricultural sector should be increased.
- **Accelerating the rollout of adaptation solution**, as solutions are urgently needed to help farmers and land managers tackle climate risks.
- Ensuring the availability and sustainability of freshwater by **sharply reducing water use**. To this end, the Commission intends to **promote a wider use of Drought Management Plans**. Promoted measures include water retention capacity of soils and safe water reuse, high tech (support precision farming) and nature-based solutions to ensure a more sustainable use of water", which are also measures that can improve the resilience of the agricultural sector regarding climate change. This could also be supported by national Common Agricultural Policy Strategic Plans.

In 2019, 28 European countries (25 EU MS and 3 EEA member countries) have adopted their National Adaptation Strategy (NAS) and 17 European countries (15 EU MS and 2 EEA member countries) have

developed their National Adaptation Plan (NAP). According to the Monitoring Mechanism Regulation (MMR), all of the NAS explicitly addressed the agriculture sector as one of the priority sectors. In addition, various Member States mainstreamed climate change adaptation into national agricultural policies, and several Member States developed specific adaptation strategies for the agriculture sector, based on specific Climate Change Impacts and Vulnerability assessments (CCIV).

Figure 8: Overview of the EU Member States' NAS/NAP, impacts assessments (CCIV) and adaptation measures addressing explicitly the agricultural sector

Country	Agriculture addressed in NAS/NAP as a priority sector	Specific CCIV assessment for agriculture prepared	Specific adaptation measures for agriculture defined
Austria			
Belgium			
Bulgaria	NAS/NAP not available		
Cyprus		Information not provided	Information not provided
Czechia			
Germany			
Denmark			
Estonia			
Greece			
Spain			
Finland			
France			
Croatia	NAS/NAP not available		
Hungary			
Ireland			
Italy			
Lithuania			
Luxemburg			
Latvia	NAS/NAP not available		
Malta			
Netherlands			
Poland	Information not provided	Information not provided	Information not provided
Portugal			
Romania			
Sweden			
Slovenia			
Slovakia			
United Kingdom			

Agriculture being addressed	Agriculture not being explicitly addressed	information not available

Source : (European Environment Agency. 2019)

4.1.3. Potential of EU land use policies and plans to strengthen the resilience of the agricultural sector with regards to climate change, and main gaps identified

Table 11: Potential of EU land use policies and plans to strengthen the resilience of the agricultural sector with regards to climate change

Instruments at EU level	Adaptation issues addressed by the policy?	Planning documents at MS level
LULUCF Regulation for 2021-2030	Indirectly	No planning documents associated. Specific measures related to LULUCF regulation should be integrated in individual National Energy and Climate Plans

Legend:

Binding instrument	Non-binding instrument

Source: Authors

The main focus of the Land use, land use change and forestry (LULUCF) Regulation is on increasing carbon capture and storage in agriculture and forestry sectors, in order to be consistent with the EU 2030 climate ambition to reach at least 55% net greenhouse gas emission reductions by 2030 compared to 1990 levels, enabling a gradual and balanced trajectory towards climate neutrality by 2050. However, as the LULUCF regulation has important implications for land cover change, the accompanying measures which include maintenance of grasslands, carbon farming and restoration of peatlands, will also help prevent soil erosion and reduce flooding risk, thus contributing to the overall resilience of the sector.

So far, no European planning documents support the implementation of the LULUCF Regulation at MS level. Rather, it is up to the Member States to propose measures in their National Energy and Climate Plans in order to achieve the objectives set out at the European level.

4.1.4. Potential of EU biodiversity and food policies under the Green Deal and plans to strengthen the resilience of the agricultural sector with regards to climate change, and main gaps identified

Table 12: Potential of EU biodiversity and food policies under the Green Deal and plans to strengthen the resilience of the agricultural sector with regards to climate change

Instruments at EU level	Adaptation issues addressed by the policy?	Planning documents at MS level
EU Biodiversity Strategy for 2030 (COM(2020) 380)	Yes	No planning documents associated. Specific measures related to the EU Biodiversity Strategy should be integrated in individual CAP Strategic Plans
EU Soil Strategy for 2030 (COM(2021)699	Yes	No planning documents associated.
Farm to Fork Strategy (COM(2020) 381)	Yes	No planning documents associated so far. Specific measures related to the EU Biodiversity Strategy should be integrated in individual CAP Strategic Plans. But the European Commission is currently putting together a legislative proposal (due by the end of 2023) to ensure transition to a sustainable food system that has a positive environmental impact, helps mitigate climate change, ensures food security and fosters competitiveness of the EU supply sector[20].

[20] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy/legislative-framework_en

EU Nature Restoration Law 2022/0195	Yes	

Legend:

Binding instrument	Non-binding instrument

Source: Authors

The Biodiversity Strategy for 2030 is a key component of the European Green Deal, including through its objectives to "bring back nature to agricultural land". Indeed, while agriculture is one of the main drivers of biodiversity decline, improving the condition and diversity of agroecosystems and restoring ecosystems services will increase the resilience of the sector to climate change. Therefore, specific commitments to be delivered under the strategy by 2030 include "establishing biodiversity-rich landscape features on at least 10% of farmland, and managing 25% of agricultural land under organic farming, while also promoting the uptake of agro-ecological practices".

To date, no European regulation supports the implementation of the Biodiversity Strategy. Rather, it was decided that it is up to the Member States to propose measures, in their individual CAP Strategic Plan, that strive achieve the objectives set out in this strategy, notably by promoting eco-schemes and result-based payment schemes. Nevertheless, the Commission **proposed a Nature Restoration Law** to set legally binding targets for nature restoration in different ecosystems, including agroecosystems. The aim is to cover at least 20% of the EU's land and sea areas by 2030 with nature restoration measures and extend these to all ecosystems in need of restoration by 2050. In agricultural ecosystems, the proposal would request an overall increase of biodiversity and a positive trend for grassland species, organic carbon in cropland mineral soils and high-diversity landscape features. Furthermore, the law proposes the restoration and rewetting of drained peatlands under agricultural use.

The **EU Farm to Fork Strategy** seeks to rethink the whole food value chain in order to improve its sustainability. It aims to reduce the environmental and climate footprint of the EU food system and strengthen its resilience, ensure food security in the face of climate change and biodiversity loss and lead a global transition towards competitive sustainability from farm to fork and tapping into new opportunities. The strategy sets out to reduce fertiliser use by at least 20% and nutrient losses by 50%, while ensuring there is no deterioration in soil fertility, and it also aims to reduce the overall use and risk from chemical pesticides and the use of more hazardous pesticides by half by 2030. The Commission has proposed to adopt a legislative framework for sustainable food systems by the end of 2023 and set rules to reduce the use of chemical pesticides, such as legally binding targets at EU and national level to reduce the use and risk of chemical pesticides, and a ban on all pesticides in sensitive areas.

The **Soil Strategy for 2030** aims to address "challenges of achieving climate neutrality and becoming resilient to climate change, developing a clean and circular (bio)economy, reversing biodiversity loss, safeguarding human health, halting desertification and reversing land degradation" by restoring soil ecosystem health. This strategy is anchored in the EU biodiversity strategy for 2030 and the Climate Adaptation Strategy. The implementation of this strategy calls for private finance (notably through carbon payments schemes) and EU funding provided by the CAP, LIFE programme of Horizon Europe. This strategy is also revelant to the issue of increasing the resilience of agriculture to climate change, as healthy soils, owing to improved water retention capacity, are proven to be more resilient to flood events. Moreover, the soil is also a habitat for biodiversity which positively interacts with agriculture (see paragraph above on the Biodiversity Strategy).

Together, the strategies and current proposal on biodiversity and food under the Green Deal reinforce several measures supporting adaptation and enhanced resilience in agriculture, such as improving soil

health (to enhance carbon soil content and soil water retention), crop rotation and diversification (to reduce pest pressure), pasture and grazing management, floodplain and peatland drainage management (to reduce flood damage) and landscape design including features such as tree shelters. However, no specific funds have been allocated to their implementation. The objectives set out by these Strategies can only be attained through measures deployed by each Member States in their CSP, notably by promoting eco-schemes, result-based payment schemes, research, innovation and investments.

4.2. Role of the CAP for supporting the agricultural sector to pro-actively mitigate effects of extreme weather and shielding the sector against it, both at EU and national levels

KEY FINDINGS

- The specificity of the new CAP lies in the greater flexibility granted to the Member States, which describe the national implementation of the CAP within their CAP Strategic Plan (CSP).
- Needs related to the achievement of Specific Objective 4 "Contribution to climate change mitigation and adaptation" are generally considered as high priority (level 1).
- Interventions most widely used by the Member States to respond to the challenges of adaptation are essentially direct payments (in particular through eco-schemes), sectoral interventions, ENVCLIM interventions and INVEST interventions.
- Risk management tools are rarely cited as instruments that specifically address adaptation of the agricultural sector to climate change (SO4). Rather, they are seen as tools to increase the overall resilience of the agricultural sector (SO1) in general. But generally, there is still an under-use of risk management tools (insurance, mutual insurance) within the Member States, and a weak mobilization of CAP measures to support their implementation.
- Regarding CAP interventions that can support practices related to the prevention of flood damage, most of the Member States propose in their CSPs interventions favourable to soil structure, notably by promoting rotations, plant cover and limiting tillage. A relatively high number of MS also support the maintenance or establishment of landscape elements such as hedges or buffer zones.
- Regarding CAP interventions that can support practices related to the prevention of drought and water scarcity damages, Member States propose in their CSPs interventions that promote more efficient use of irrigation water, but also interventions that increase water retention in soils and the landscape, interventions targeting crop rotation, crop diversification and adoption of more drought and heat tolerant species. Some MS also support interventions favourable to the improvement of pasture grazing management, matching for instance stocking densities to forage production, to address the risk of a lack of forage in the case of drought events.
- Practices that can help prevent frost, hail and storms damages are somewhat supported by eco-schemes and ENVCLIM interventions, but more so by INVEST interventions.

4.2.1. Potential of the CAP to strengthen the resilience of the agricultural sector with regards to climate change at the EU level

Table 13: Potential of the CAP to strengthen the resilience of the agricultural sector with regards to climate change at the EU level

Instruments at EU level	Adaptation issues addressed by the policy?	Planning documents at MS level	Adaptation options promoted in the planning documents?	Agri. issues regarding climate change addressed?
Common Agricultural Policy (CAP), governed by three main regulations: - Regulation (EU) 2021/2115 - Regulation (EU) 2021/2116 - Regulation (EU) 2021/2117	Yes	National Strategic Plans	See the analysis provided below	Yes

Legend:

Binding instrument	Non-binding instrument

Source: Authors

In early December 2021, the agreement on the reform of the Common Agricultural Policy (CAP), for the 2023-2027 period, was formally adopted by the European Parliament and the Council of Agriculture Ministers. This agreement concerns 3 regulations:

- A regulation governing support for strategic plans (Reg. (EU) 2021/2115),
- A regulation on the financing, management and monitoring of the CAP (Reg. (EU) 2021/2116),
- A regulation on the common organization of the markets in the agricultural products sector (Reg. (EU) 2021/2117).

The new CAP targets 10 specific objectives (SO) related to sustainable development (social, environmental, economic) and is a key element in achieving the objectives set out in the European Green Deal and the Farm to Fork Strategy. Among its specific objectives, the new CAP seeks to make the European agriculture more resilient to climate change (SO4): "Contribution to climate change mitigation and adaptation".

The particularity of the new CAP lies in the greater flexibility granted to the Member States. Indeed, each Member State submitted a CAP Strategic Plan (CSP) that describes the national implementation of the CAP to the European Commission. These CSPs were all validated by the EC before the start of the new CAP on January 1st, 2023. In the CAP strategic plan, each Member State must present how it plans to use the CAP interventions (direct payments, sectoral and rural development interventions) to meet the objectives defined by the European Commission and contribute to the ambition of the Green Deal.

The following paragraphs provide a cursory insight into how adaptation of the agricultural sector to climate change, notably to extreme weather events, has been addressed by the new CAP under conditionality, under interventions in the form of direct payments and under rural development interventions (European Parliament and of the Council 2021).

Enhanced conditionality:

Cross-compliance is a crucial aspect of the green architecture of the new CAP. The objective of conditionality is to ensure that farmers receiving direct support respect basic environmental and climate standards. The CAP Strategic Plan Regulation sets out nine standards for Good Agricultural and

Environmental Condition (GAEC), stemming from cross-compliance and the greening measures of the 2014-2022 CAP.

Table 14: List of GAECs in the new CAP

Main subject	GAEC
Climate Change : Adaptation and mitigation	GAEC 1: Maintenance of permanent grassland based on a ratio of permanent grassland to agricultural area established at national, regional, subregional, group-of-holdings or holding level in comparison to the reference year 2018
	GAEC 2: Protection of wetlands and peatlands
	GAEC 3: Ban on burning stubble, except for phytosanitary reasons
Water	GAEC 4: Creation of buffer strips on the banks of rivers
Soil	GAEC 5: Tillage management to reduce the risk of soil degradation, including slope consideration
	GAEC 6: Minimum soil cover to avoid bare soils in the most sensitive period(s)
	GAEC 7: Crop rotation on arable land, except for crops under water
Biodiversity and Landscape	GAEC 8: Minimum share of agricultural area devoted to non-productive areas or features, including land lying fallow; conservation of landscape features and prohibition of cutting hedges and trees during the breeding and breeding season of birds.
	GAEC 9: Prohibition to convert or plough permanent grassland designated as ecologically sensitive permanent grassland in Natura 2000 sites

Source: Authors

The overall design of GAEC standards is carried out at EU level. However, Member States then set national standards for each of these standards according to their specific national context (e.g., climatic conditions, farming practices, etc.). Thus, the CAP legislation allows Member States to set additional standards related to the main objectives of the GAECs. Moreover, the CAP Strategic Plans Regulation provides various exemptions to the general rules.

At this stage, it is difficult to say whether some of the GAECs designed by Member States appear sufficiently ambitious to address climate change adaptation needs.

Interventions in the form of direct payments:

Greening payments from the 2014-2022 CAP were replaced by a new measure in the 2023-2027 CAP, i.e., the Eco-scheme regime (Art 31). **Eco-schemes** intend to foster practices that go above and beyond GAECs and the national and European regulations. Thus, to strengthen the CAP's environmental dimension beyond the baseline guaranteed by cross-compliance, Member States can set up eco-schemes. At least 25% of the budget for direct payments must be dedicated to eco-schemes. The list of agricultural practices that can be targeted by eco-schemes was published by the EC (European Commission 2021). Next, each Member State proposed their own eco-schemes, which are required to both comply with needs at the national level and cover at least two 'areas of action'. The eight areas listed in the regulation are: climate mitigation; climate adaptation; water protection; soil protection; protection of biodiversity; sustainable and reduced use of pesticides; and enhanced animal welfare or actions addressing antimicrobial resistance. These eco-schemes, which are optional for farmers, correspond to a payment granted either to encourage and remunerate the supply of public goods through agricultural practices beneficial for the environment and the climate, or as compensation for the implementation of these practices.

In addition, coupled income support can support protein and leguminous crop sowing, which can be relevant regarding some of the farm practices mentioned earlier to cope with climate change impacts and address food security issues. Moreover, 15% of the budget for operational sectoral programs (fruit

and vegetables, wine, etc.) must be dedicated to environmental and/or climate actions (Regulation 2021/2115 Chapter 4).

Finally, in the Farm to Fork Strategy the European Commission committed itself to revamping the agricultural crisis reserve "so its full potential can be used upfront in the case of crisis in agricultural markets". It has recently led to the setting-up of the European Food Security Crisis preparedness and response Mechanism (EFSCM), convening European and national administrations and private actors all along the supply chain (European Commission 2022b). This mechanism is funded from the direct payment budget and can be used to respond to a food security crisis linked to an extreme climate event. If unused, the envelope is redistributed in the form of direct payments in the same year (OECD 2021).

Rural development interventions:

In the new CAP, at least 35% of the European Agricultural Fund for Rural Developments (EAFRD) will be allocated to measures to support climate, biodiversity, environment and animal welfare. Among the measures that can support adaptation of the agricultural sector to climate change, the following may be deployed by Member States.

Envclim (Art 70): Member States can set up interventions promoting "Environmental and climate commitments and other management commitments". These commitments, over a period of 5 to 7 years, concern practices that go beyond conditionality and mandatory requirements established by national and Union law and should be different from eco-schemes. The payments to be made are based on additional costs incurred and the loss of income resulting from the commitments made by farmers. Envclim measures correspond to Agri-environmental and climate measures (AECMs) from the previous CAP.

Invest (Art 73 and 74): Member States may grant aid to support investments which contribute to the achievement of one or more of the specific objectives. The intervention can, for instance, support investments that can contribute to climate change adaptation within the sector (ex. improving efficiency of existing irrigation systems). The rate of aid is limited but may reach 100% in some cases. Full funding can apply to investments related to the restoration of agricultural or forestry potential following a natural disaster or investments linked to the establishment of agro-forestry systems, for instance.

Risk management tools (Art 76): Member States may grant support for risk management tools which can help farmers to manage production and income risks related to their agricultural activity and over which they have no control. Member States can support different types of risk management tools such as financial contributions for the payment of pension schemes, financial contributions to insurance premiums and financial contributions to mutual funds. Member States shall ensure that aid is granted only to cover losses exceeding at least 20 % of the average annual production or the average annual income of the farmer. Sector risk management tools calculate losses either at the farm level or at the level of farm activity in the relevant sector.

Based on information provided by Member States in their CSP, the European Commission will assess the contribution of the policy to the achievement of climate change objectives.

4.2.2. Main interventions mobilized by Member States to address climate change adaptation needs related to the achievement of the SO4

This part focuses on the main interventions mobilized by each Member State[21] to address climate change adaptation needs related to the achievement of SO4 "Contribution to climate change mitigation and adaptation". In this section a summary at the European level is presented (the results of this analysis country by country are analysed Annex D.).

The objective SO4 "Contribution to climate change mitigation and adaptation" brings together both needs relating to GHG mitigation issues and needs relating to adaptation issues. The analysis conducted for this study shows that, in the CSPs analysed, there are more needs relating to mitigation than adaptation. In addition, the needs related to adaptation are often quite small in number and not very precise, without any mention of extreme events. For example, Belgium Wallonia, Croatia, Ireland, Latvia, Lithuania, Portugal and Sweden, have only one need directly related to climate change adaptation (see Table 15 below). However, some Member States are more specific about their adaptation needs, particularly regarding the increase in extreme events. For example, Spain has identified five needs related to adaptation under SO4, two of which directly mention the issue of adaptation to extreme climate events. Similarly, Estonia has identified four needs related to adaptation under SO4, one of which directly mentions the issue of adaptation to extreme weather events.

Other needs may have been identified by Member States as not contributing to the SO4 objective, although they may nevertheless support adaptation practices. For example, the use of risk management tools is often described in the different CSPs as a need related to the SO1 "Support viable farm income and resilience of the agricultural sector across the Union in order to enhance long-term food security and agricultural diversity as well as to ensure the economic sustainability of agricultural production in the Union". Similarly, needs related to the preservation of soil from erosion or to quantitative management of water are usually described under SO5 "Foster sustainable development and efficient management of natural resources such as water, soil and air, including by reducing chemical dependency". Interventions programmed by Member States under those needs aimed at maintaining farmers' income or preserving the environment, although their contribution to the adaptation of the agricultural sector is significant.

Next, needs are classified regarding their level of priority. It is observed that needs related to adaptation to climate change are generally considered as high priority (level 1), but not for all Member States. For instance, for Belgian Wallonia, Ireland, Lithuania and Sweden, climate change adaptation needs appear to be lower priority (priority 2 or 3) compared to other needs.

Table 15: Needs related to adaptation to climate change in the SO4 and their level of priority

Country	Identification of needs related to adaptation (SO4)	PRIORITY
AUSTRIA	B14 - increasing resilience and Adaptation to climate change	1
	B17 - Preservation and expansion of climate-friendly and site-adapted animal husbandry	1
BELGIUM WA	4.14 - Increasing the resilience of farms and forests to climate change	2
CROATIA	07- Improve practices that contribute to climate change adaptation and mitigation	1
DENMARK	D1- Promote climate-friendly agricultural production	1
	D2- Expansion of the forest area to mitigate climate impact.	2

[21] As the analysis was carried out in early December 2022, not all CSP had been finalised by the Member States and officially validated by the European Commission. Therefore, the analysis focused on 18 CSP out of 27, i.e., those that were already validated at that time: Austria (AT), Belgium Wallonia (BE-WA), Germany (DE), Denmark (DK), Estonia (EE), Greece (EL), Spain (ES), Finland (FI), France (FR), Croatia (HR), Ireland (IE), Lithuania (LT), Luxembourg (LU), Latvia (LV), Poland (PL), Portugal (PT), Sweden (SE) and Slovenia (SI).

Country	Identification of needs related to adaptation (SO4)	PRIORITY
	D3- Increase incentives for climate-related investments.	1
ESTONIA	V4.1 - Increase awareness of the mutual impact of climate, its changes and agriculture	1
	V4.6 - Ensure adaptation to climate change in crop production	1
	V4.1 - Increase awareness of the mutual impact of climate, its changes and agriculture	2
	V4.5 - To promote land improvement investments mitigating weather risks	3
FINLAND	Beta 09 - Promoting adaptation to the impacts of climate change	1
	Beta 08 - Taking climate and environmental impacts into account, promoting resource efficiency and the circular economy	3
FRANCE	D7 - Make systems more resilient (adaptation: prevention/ management)	1
	D2 - Support global levers (beyond climate issues)j	1
GERMANY	D.3 Adaptation of agriculture and forestry to climate change	1
	D.7 Flood protection, coastal protection and natural water retention improvement	1
GREECE	IF 035.04.02 - Redesign policy on adaptation of agriculture and forestry to climate change	1
	IF 055.04.03 - Information-training and advice on mitigation-adaptation actions (AKIS)	3
IRELAND	Obj4.N4 - Encourage climate adaptation	3
LATVIA	SM4 V7 - Support climate change adaptation implementation of measures	1
LITHUANIA	D.4 - Increase farm resilience to climate change risks through modern water management systems	3
LUXEMBOURG	B4.3 - Promote the efficient use of water resources	1
	B4.5 - Provide resilience in the face of climate change	2
POLAND	CS 4. P2 - Adaptation of agriculture and forestry to climate change — reducing weather and disease risks	1
	CS 4. P6 - Raising knowledge on climate change mitigation and adaptation	Beyond Priority
PORTUGAL	PTOE4N1- Increasing resilience to climate change impacts — extreme climate events	1
SLOVENIA	P14- Maintaining and ensuring the quality of agricultural soils and preventing erosion	1
	P15-Adaptation to climate change in agriculture and forestry	1
SPAIN	04.03 - Reduce the vulnerability of agricultural, livestock or forestry systems to the impacts of climate change and extreme events by encouraging their adaptation	1
	04.04 - Promoting the diversification of production and the inclusion of crops and breeds with greater potential for adaptation to climate change due to their lower vulnerability in future climate change scenarios	2
	04.09 - Knowledge transfer in mitigation and adaptation	2
	04.07 - R & D & I on climate change mitigation and adaptation	3
	04.10 - Minimising the risks due to extreme weather events, in addition to enhancing agricultural insurance systems in relation to the adversities of the sector due to the effects of climate change	3
SWEDEN	SO4BEHOV3 Adapt production to climate change and reduce relative impact on the climate	2

Source: CAP Strategic Plans from the concerned Member States

The next table presents the major instruments of the CAP that are identified by Member States as competent to address climate change adaptation needs, related to the achievement of SO4. Additional instruments – that are reported in Annex D. - outside the CAP can also be mobilised by Member States to achieve SO4.

Table 16: Main instruments mobilized to address adaptation needs in response to SO4

Main instruments mobilized to address adaptation needs (SO4)	AT	BE-WA	DE	DK	EE	EL	ES	FI	FR	HR	IE	LT	LU	LV	PL	PT	SE	SI	Total
DIRECT PAYMENTS - Eco scheme	4	3	2	5		4	5	1	1	6	1		1	3	2		1	8	47
DIRECT PAYMENTS - Associated Income Assistance													1						1
SECTORAL INTERVENTIONS		1	3	4		3	4		4	2	4	1		6	4	1	2	2	41
RURAL DEVELOPMENT – ENVCLIM	2	2	2	1	1	3	4	10	6	4	2		1	2	4	9		5	58
RURAL DEVELOPMENT - Specific disadvantages				1			1												2
RURAL DEVELOPMENT – INVEST	1	3	1	4	4	3	5	4	2		2			3	1	12	1	5	51
RURAL DEVELOPMENT – RISK MANAGEMENT TOOLS									2										2
RURAL DEVELOPMENT – COOP		1						1			2				1		2	1	8
RURAL DEVELOPMENT – KNOW					2	2			1						4	2	1	1	13
Total number of measures related to adaptation needs under SO4	7	10	8	15	7	15	19	16	16	12	11	1	2	14	16	24	7	22	

The country presents at least one measure in this intervention areas to meet needs related to adaptation under the SO4. The number of measures promoted under each intervention is itemized in each cell

Source: Authors, from CAP strategic plans of the concerned Member States

In order to respond to the adaptation needs related to the SO4, some Member States consider using a wide range of instruments (DK, EL, ES, FI, FR, PL, PL, PT, SI), while for others it is much more limited (AT, BE-WA, EE, LT, LU, SE).

The instruments most used by the Member States to respond to the challenges of adaptation in relation to the specific objective SO4 are essentially direct payments (through eco-schemes), sectoral interventions, ENVCLIM interventions and INVEST interventions.

Most direct payment interventions mobilized to respond to SO4 correspond to Ecoschemes. Luxemburg is the only Member State that offers in its CSP an Associated Income Assistance intervention responding to the needs of adaptation in the SO4. This intervention is "1.03.503 - Legumes coupled aid" which is linked to the need "B4.6 - Improve forage autonomy". Although other Member States have implemented a similar intervention (such as France), it is not linked to the SO4 in their CSP.

COOP interventions (cooperation between at least 2 economic actors), especially through the preparation and implementation of the EIP operational group projects[22], and KNOW interventions are also opted for by several MS to achieve the SO4. Such interventions which promote cross-cutting measures remain crucial in the perspective of anticipating and responding to extreme climate events (see section 2.1).

Risk management tools are, at this stage, very rarely cited as instruments that specifically address adaptation of the agricultural sector to climate change (SO4). Rather, they are seen as tools to increase the overall resilience of the agricultural sector (SO1) in general. While most Member States consider using a wide range of instruments to address climate change adaptation needs, for most it is not clear stated in the CSPs how these instruments will be linked together and how instruments mobilized inside and outside the CAP will be articulated.

Box 2: Example of the articulation between interventions aimed at erosion control in the Finnish CSP

Erosion control in the Finnish CSP is supported by different complementary instruments:

(i) GAEC 6 requires that at least 33% of the farmer's arable land and permanent crops area be covered by a cover crop in winter,

(ii) an Ecoscheme has been set up to promote the implementation of a cover crop between the autumn harvest and the spring sowing (Ecoscheme 01 - Winter cover crop": 50 EUR/ha),

(iii) implementation of soil structure improvement crops is promoted by ENVCLIM measures (ENVCLIM Environment 02 - Soil improvement and restoration plants: 190 EUR/ha)

(iv) investment in equipment to limit soil compaction is promoted by INVEST measures (INVEST Agriculture 03 – Investments for the environment and sustainable production in agricultural holdings: 40% of eligible costs).

Table 17: Complementarity between Finnish CSP interventions promoting erosion control

Type of intervention	GAEC	Eco-scheme	ENVCLIM	INVEST
Name of the intervention	GAEC 6	Eco-system 01 — Winter vegetation cover	Environment 02 — Land Improvement and Restoration Plants	Inv Agriculture 03 — Investments for the environment and sustainable production on farms
Description	33% of the farmer's arable land and permanent crops area must come from plant cover in winter	Cover crop between autumn harvest and spring sowing in the Eco-schemes	Crops to improve soil structure	Investment in equipment to limit soil compaction
Level of aid	Requirement	EUR 50/ ha	EUR 190/ha	40% of the eligible costs

Source: Authors

[22] Operational Groups are intended to bring together multiple actors such as farmers, researchers, advisers, businesses, environmental groups, consumer interest groups or other NGOs to advance innovation in the agricultural and forestry sectors.

The effective articulation and complementarity between interventions aiming to increase agricultural sector resilience to climate change, in order to meet adaptation objectives, will be a crucial point for further assessment during the CSP implementation period.

4.2.3. Main adaptation solutions supported by Member States through specific interventions in their CSPs

Table 18 gives an overview, at the European level, of the extent to which Member States[23] have planned to support adaptation practices (from the list established in section 3.2.1, Table 6) through CAP measures deployed under the following intervention areas: Eco-schemes, Envclim and Risk Management Tools. Results of this screening are available in annex D, for each CSP analysed[24].

The focus is on the Eco-schemes and Envclim areas of intervention, as they promote interventions carrying strong potential to help prevent the impacts of extreme events and respond to them. The measures related to Risk Management Tools have also been targeted for this analysis, as they bear strong potential to help the sector to recover from extreme events.

The analysis included all measures that could contribute to climate change adaptation under these three intervention areas, whether they were listed as contributing to SO4 or not.

[23] As the analysis was carried out in early December 2022, not all CSPs had been finalised by the Member States and officially validated by the European Commission. Therefore, the analysis focused on 18 CSPs out of 27, i.e., those that were already validated at that time: Austria (AT), Belgium Wallonia (BE-WA), Germany (DE), Denmark (DK), Estonia (EE), Greece (EL), Spain (ES), Finland (FI), France (FR), Croatia (HR), Ireland (IE), Lithuania (LT), Luxembourg (LU), Latvia (LV), Poland (PL), Portugal (PT), Sweden (SE) and Slovenia (SI).

[24] For each, CSP a keyword search was performed to conduct this screening (the list of of keywords used is presented in the Annex E.). The analysis encompassed measures that are also promoted outside the SO4.

Table 18: Major adaptation solutions supported by MS in their respective CSP under the following intervention areas: Eco-schemes, Envclim and Risk Management Tools

Primary risk faced	Adaptation solutions supported	AT	BE	DE	DK	EE	EL	ES	FI	FR	HR	IE	LT	LU	LV	PL	PT	SE	SI
Flood risk	Enhance flood plain management																		
	Ecosystem compatible drainage																		
	Improve pasture and grazing management to reduce grazing pressures																		
	Improve soil structure to increase water retention capacity and improve drainage																		
	Intercept rainfall to increase water availability																		
	Landscape design using hedgerows, buffers, tree shelters																		
Risk of drought and water scarcity	Improve irrigation efficiency and water use																		
	Improve soil moisture retention capacity																		
	Better manage crop water demand																		
	Implement crop diversification and rotation																		
	Introduction of more heat tolerant species/breeds																		
	Increase shelter for animals																		
	Improve pasture and grazing management to match stocking densities to forage production																		
	Plan feed alternatives in case of drought																		
Risk from frost, hail and storms	Active protection against frost																		
	Shade and nylon hail protection nets for orchards																		
	Use of greenhouses to protect vegetables																		
	Develop agroforestery within silvo-arable or silvo-pastoral systems																		
Combined risk from extreme weather	Acquire insurance products for climate and weather risks																		
	Other risk management tools																		
	Use of precision farming																		
	Farm activity and production diversification																		

Legend

- The MS has at least one eco-scheme measure which supports the practice
- The MS has at least one measure related to ENVCLIM which supports the practice
- The MS has at least one measure related to Risk Managment Tools which supports the practice

Measures tackling the risk of floods

Regarding CAP interventions that can support practices related to the **prevention of flood damages**, most of the Member States offer interventions favourable to soil structure in their CSPs, notably relying on crop rotations, plant cover and reduced tillage. For example, in the Croatian CSP one Eco-scheme targets these practices through "31.06. Conservation agriculture" (see Box 4). However, the support for crop rotations must be compared to existing crop rotations within each Member State to evaluate their true level of ambition. Member States have also implemented interventions that support extensive livestock farming to reduce pressure on pastureland, although reducing grazing density is not directly targeted. Luxembourg's ENVCLIM intervention "2.02.550 - Help to reduce cattle load" is one of the few that implies a reduction of the cattle herd in relation to the average size of the cattle herd on the farm (at least 15% in terms of bovine Livestock Unit) and imposes limits on the stocking rate of herbivorous livestock per ha of fodder area (between 0.5 and 1.8 LUs /ha). Moreover, Germany's ENVCLIM intervention "EL-0101-04: Water retention in the landscape", is one of the few interventions that support rainfall interception practices. Finally, a relatively high number of Member States also support the maintenance or establishment of landscape elements such as hedges or buffer zones.

Box 3: How the Austrian eco-scheme goes beyond conditionality.

Austria implemented various eco-schemes in order to reduce soil erosion. The eco scheme "31-03 – Erosion protection Wine, fruit and hops" is a good example demonstrating how the intervention can go beyond conditionality.

First, the GAEC 05 requires "On permanent crop areas without greening of the lanes and a predominant inclination from 10 % on the lower edge, a strip of at least 5 m wide with soil-covering vegetation shall be applied". Moreover, the GAEC 06 requires for "Areas of fruit, viticulture and hops with a rest period between grubbing-up and new planting of at least one growing season shall be greened for the duration of the resting period" and "at least 50 % of the permanent crop areas of the holding shall have minimum soil cover between 01.11. and 15.02".

How the intervention is complementary and goes beyond the GAECs:

The eco-scheme 31-03 goes beyond GAECs as it requires for instance a greening **all year long in all lanes** on all vineyards, orchards and hops on the farm by sowing green crops with at least three winter-hardy mixing partners, leaving existing crops between the rows of permanent/special crop areas or cultivating terraces. Soil tillage during the greening period is only permitted if the greening is not destroyed (e.g., subsoil or deep loosening) or the new planting takes place afterwards.

Furthermore, this eco-scheme sets a requirement linked to the reduced use of plant protection products on the greening, instead promoting the use of pheromones or auxiliary organisms.

Box 4: Support of conservation agriculture through the Eco-scheme 31.06 of Croatia

Conservation agriculture aims to ensure optimal functioning of the soil and improve its properties compared to its initial state. It is based on 3 main principles: reduction (or even the elimination) of tillage, permanent soil cover using plants or plants residues and crop diversification and rotation. This set of practices can also help prevent flood damage.

Requirement for the intervention 31.06. Conservation agriculture of the Croatian CSP:

"When implementing the intervention in the claim year, the beneficiary is obliged to carry out the following:

1. Carry out reduced tillage, which does not overturn the soil.
2. On arable land spend a minimum of two-field crop rotation on each ARKOD plot. Catch crops and green cover crops may constitute components of crop rotation.
3. After all work operations, ensure full coverage of the soil of agricultural land with plant residues or green cover.
4. Maintain an agricultural area from weed vegetation according to the principles of integrated pest management with the obligation to apply mechanical measures.
5. Complete training or use individual counselling or take part in a demonstration activity of at least 6 hours on the topic of eco- scheme Conservation Agriculture (Basic information on conditionality, Place and role of eco-scheme Conservation agriculture among other eco-schemes, Features of reduced tillage, Integrated protection of arable crops from weeds, Mechanical weed removal, soil cover in conservation agriculture).
6. Keep records of the implementation of all obligations according to the prescribed form.

The form of records shall be submitted by the beneficiary to the Paying Agency for Agriculture, Fisheries and Rural Development by 31 December of the year of submission of the application."

The support for conservation agriculture is implemented through a grant which compensates the costs and loss of revenue resulting from this commitment, amounting to EUR 250/ha. Moreover, this intervention can be combined with other eco-scheme interventions.

How the intervention is complementary and goes beyond the GAEC:

This intervention goes beyond the Croatian conditionality because GAEC 6 requires a minimum land cover to avoid erosion and GAEC 7 requires a crop rotation at least once a year (not applicable for holdings where more than 75% of areas are grasses, permanent grasses or other herbaceous forage, the production of legumes or land lying fallow).

Measures tackling the risk of droughts and water scarcity

Regarding CAP measures that can support practices related to the prevention of drought and water scarcity damages, Member States propose in their CSPs interventions that promote **more efficient use of irrigation water**, thereby reducing pressure on water resources and reducing vulnerability to scarcity and droughts. France for instance has introduced 2 ENVCLIM interventions "FR 70.06 - Agri-environmental and climatic measure for the quality and quantitative management of water for arable crops and FR 70.07 - for perennial crops", which encourage farmers to reduce irrigation (See Box 5). Investment interventions are often proposed to improve the efficiency of existing irrigation systems, with up to 50% water savings required when the water body status is "less than good" according to the EU WFD – thereby increasing the resilience of the agriculture sector and linked aquatic ecosystems. Investments are also planned to increase the net irrigated area as in Croatia and Greece. To protect ecosystems and make them resilient to climate change impacts, some countries establish new requirements alongside the provision of support to increase the net irrigated area. For instance, Greece requires that the linked water body should not be "less than good" status for reasons related to the quantity of water and that the investment does not cause significant environmental impacts.

Member States also support interventions that increase water retention in soils and the landscape. Water retention is a common topic across CSPs either for flood risk or drought and water scarcity management. It is promoted via building soil carbon content and more generally improving soil health. Slovenia for instance supports an eco-scheme "INP 08.07 Preserving soil" which aims to increase soil water retention capacities. With regards to ENVCLIM, Germany supports "EI-0103 — Management

commitments to improve soil protection" which aims to meet the need to reduce water consumption with regards to the soil and landscape water balance.

More frequently planned, but with a more indirect effect on tackling drought risks and water scarcity, interventions targeting crop rotation, crop diversification and adoption of more drought and heat tolerant species. For example, the eco-scheme of Greece "P1-31.1 — Use of resistant and adapted species and varieties" support the use of drought resistant crops and supports switching from summer water intensive crops to winter crops.

Similarly, Member States support interventions favourable to the improvement of pasture grazing management, matching for instance stocking densities to forage production. This can indirectly contribute to managing the risk of a lack of forage due to drought impacts. Slovenia for instance supports an ENVCLIM intervention "IRP18.01 Agri-environment-climate payments" which aims, amongst others, to contribute to the need to adapt to climate change by optimizing feeding strategies.

Box 5: Support for water management through the ENVCLIM 70.06 - Agri-environmental and climatic measure for the quality and quantitative management of water for arable crops of France

One component of this measure concerns quantitative water management on arable farms. This intervention is systemic because the farmer must implement various practices to receive the payment. Under this intervention, farmers voluntarily commit to implementing the planned practices for 5 years.

Three levels of remuneration are provided linked to different practices:

1. Level 1 requires the establishment of:
   - crops that consume little water (buckwheat, hemp, sorghum, sunflower, soybeans, lupins, temporary meadows, leguminous/cereal associations, etc.),
   - the prohibition to renew the same crop as the year previous crop over at least 90% of the surface,
   - the diversification of crops (either at least 1 winter crop, 1 spring crop, 1 BNI or legume, or at least 2 years of perennial legumes or temporary grassland)
   - the planting installation of non-productive elements such as hedges or cover favourable to pollinators.
2. Level 2 requires the reduction of the volume of water consumed for irrigation by 15% from the third year compared to the Olympic average of the 5 years preceding the commitment.
3. Level 3 requires soil cover on 90% of arable land for at least 10 months in long intercrop and at least 11 months out of 12 in short intercrop.

Support for the implementation of practices favourable to the reduction of irrigation correspond to a compensation for the additional cost or losses generated, increased by 20%.

Total additional costs and shortfalls EUR/ha : 76 (Level 1), 99 (Level 2), 168 (Level 3), for the field vegetable crops 110,27 EUR/ha is additional

Amount of aid EUR/ha : 92 (Level 1), 119 (Level 2), 201 (Level 3)

Source :(French CSP 2022)

Measures tackling the risk of frost, hail and storm damages.

Practices that can help prevent frost, hail and storms damages are less supported by eco-schemes and ENVCLIM interventions. However, these practices can be promoted by INVEST interventions supporting the investments for infrastructures such as water retention infrastructures or active protection against frost.

Practices such as hail protection for orchards are mostly supported by sectoral interventions, for instance through the CLIMA measure for fruits and vegetable. Thus, regarding the fruit and vegetable sector, through operational programmes of producer organisations or associations of producer organisations, at least 15% of expenditure has to be dedicated to environmentally friendly practices (e.g., pest and disease resilient production practices, protection and enhancement of biodiversity and sustainable use of natural resources, in particular protection of water, soil and air, etc.), that can contribute to climate change mitigation and adaptation. For example in the Greek CSP, the intervention INVRE for fruit and vegetable (INVRE(47(1)(a)) — investments in tangible and intangible assets, research and experimental and innovative production methods and other actions) "strengthens the supply of meteorological data monitoring equipment, the supply of extreme weather protection equipment (anti-hail networks, wind heaters, rain systems, etc.) as well as other equipment or construction that helps to protect farms from extreme weather events"So far, a first non-exhaustive list of actions and expenditure that may be included in this type of intervention is provided in the CSPs, but the interventions that are actually implemented are not published yet.

Regarding the wine sector, sectoral interventions (e.g., RESTRVINEY (58(1)(a))) – restructuration and conversion of vineyards) can contribute to climate change mitigation and adaptation thanks to eligible actions such as: replanting with change of location to more optimal soil-climate areas, with varieties better adapted to soil-climatic conditions in their territory, etc.

Risk management tools

Regarding the promotion of Risk Management Tools, the analysis shows that some countries (Germany, Greece, France, Croatia, Lithuania, Latvia, Poland, Portugal) plan to support insurance systems or other risk management tools (mainly mutual funds) to respond to the challenges of the increase of extreme climatic events, through CAP funding. The eligible climatic risks are often defined through decrees or national regulations specific to each country. However, there is still a general under-use of risk management tools (insurance, mutual funds) within the Member States, and a weak mobilization of CAP measures in this area, even if some MS support national agricultural insurance system, out of the CAP (such as the Spanish agricultural insurance system, see next section).

Integration between risks, tools and measures

Finally, it should be highlighted that the interventions of eco-regimes and ENVCLIM mainly target similar practices in terms of adaptation, and that it remains difficult to assess whether these measures are thought through in a holistic way and interlinked, so as to promote systemic approaches on the farm. Indeed, some practices which have potential to support adaptation to climate change, if implemented alone without conditionality, will have harmful side effects. This is the case, for example, for zero or minimum tillage that can have harmful effects, because it can lead to a greater use of herbicides. Another example is the aid for productive investments (73.01) promoted by the French CSP. Although it can help to improve water efficiency (water savings have to be higher than 5% and higher than 50% when the water bodies are in a "less than good" conservation status), it can also lead to a potential increase in irrigated surfaces, if there is no incentive to move towards more adapted crops.

Also, while some interventions appear ambitious, their actual impact depends on the budget allocated to them and how they will be implemented regionally.

4.2.4. Evaluation and monitoring of the effects of the CAP regarding climate change adaptation

Member States' obligations on monitoring and reporting the effect of the CAP on climate change adaptation (SO4)

At Member State level, the Commission Implementing Regulation (EU) 2022/1475 sets out the rules for implementing Regulation (EU) 2021/2115 on the evaluation of the CAP Strategic Plans and the provision of information for monitoring and evaluation.

First, Member States must carry out an ex-ante evaluation (article 139 of Regulation (EU) 2021/2115) in order to assess: (i) the contribution of their CSP to the achievement of their specific objectives (SO), (ii) the consistency between the allocated budgetary resources and their specific objectives, and (iii) how the expected outputs will contribute to the results. Then, Member States must carry out evaluations of their CSPs during the implementation period of the CAP (Article 140 of Regulation (EU) 2021/2115). These evaluations aim to assess the operation, effectiveness, relevance, and consistency of the CSPs and their contribution to the achievement of their specific and general objectives. Reporting on results indicators should be done on an annual basis, through **an Annual Performance Report (APR)**[25] (European Commission 2023), but the rules for this reporting on result indicators do not seem to have been established yet in the regulation[26]. An ex-post evaluation is also expected.

Finally, Member States should ensure that they have set procedures to generate and collect the data needed for evaluations and establish an evaluation plan outlining the evaluation activities planned during the implementation period.

Table 19 gives an overview of the result indicators that Member States should assess against each specific objective[27], by selecting those relevant to climate change adaptation.

[25] According to the Cover Note on Output and Result Indicators, European Commission, 2023

[26] There is no mention of these APR in the Commission Implementing Regulation (EU) 2022/1475, nor on the reporting frequency requested by the EC.

[27] According to the Cover Note on Output and Result Indicators, European Commission, 2023

Table 19: Result indicators relevant to climate change adaptation (European Commission 2022c, 2023)

Result indicators	SO1	SO2	SO4	SO5	SO6	SO9	SO10	Description	Intervention type concerned	Unit of measu-rement	Reporting and monitoring obligation
R.5 Risk Management								Share of farms with supported CAP risk management tools (premiums for insurance schemes, mutual funds, …)	RMT Sectoral	% farm	**Annual values** Number of beneficiaries / total number of farms
R.9 Farm modernisation								Share of farms receiving investment support to restructure and modernise, including to adapt to climate change and improve water balance	INVEST Sectoral	% farm	**Cumulative values** Number of beneficiaries/ total number of farms
R12 Adaptation to climate change								Share of UAA under supported commitments to improve climate adaptation (Schemes for the climate, the environment and animal welfare, Environmental, climate-related and other management commitments, Sectoral types of interventions). Intervention on forest land are not included but agroforestry is.	Eco scheme ENVCLIM Sectoral	% UAA	**Annual values** Area under commitment / total UAA
R.14 Carbon storage in soils and biomass								Share of UAA under supported commitments to reduce emissions or to maintain or enhance carbon storage (including permanent grassland, permanent crops with permanent green cover, agricultural land in wetland and peatland). Interventions on forest land are not included.	Eco scheme ENVCLIM Sectoral	% UAA	**Annual values** Area under commitment / total UAA
R.16 Investments related to climate								Share of farms benefitting from CAP investment support contributing to climate change mitigation and adaptation, to renewable energy or biomaterials production and to improve water balance	INVEST Sectoral	% farm	**Cumulative values** Number of beneficiaries / total number of farms
R.17 Afforested land								Area supported for afforestation, agroforestry, restoration and landscape features created	INVEST Ecoscheme ENVCLIM	Ha	**Cumulative values** Total area under commitment
R.19 Improving and protecting soils								Share of UAA under supported commitments beneficial for soil management to improve soil quality and biota (such as reducing tillage, soil cover with crops, crop rotation included with leguminous crops)	Eco scheme ENVCLIM Sectoral	% UAA	**Annual values** Area under commitment / total UAA

Result indicators	SO1	SO2	SO4	SO5	SO6	SO9	SO10	Description	Intervention type concerned	Unit of measu-rement	Reporting and monitoring obligation
R.23 Sustainable water use								Share of UAA under supported commitments to improve water balance	Eco scheme ENVCLIM Sectoral	% UAA	**Annual values** Area under commitment / total UAA
R.27 Environmental / Climate performance through investment								Number of operations contributing to environmental sustainability and the achievement of climate mitigation and adaptation goals in rural areas	Genetic resources commitments INVEST COOP Sectoral	Number of operations	**Cumulative values** Number of operations receiving relevant support
R.28 Environmental / Climate performance through knowledge and innovation								Number of persons benefitting from advice, training, knowledge exchange, or participating in EIP operational groups supported by the CAP related to environmental or climate-related performance	KNOW COOP Sectoral	Number of persons	**Cumulative values**[28]
R.29 Development of organic agriculture								Share of UAA supported by the CAP for organic farming, with a split between maintenance and conversion	Eco scheme ENVCLIM Sectoral	%UAA	**Annual values** Share of UAA supported by the CAP for organic farming / total UAA
R.34 Preserving landscape features								Share of UAA under supported commitments for managing landscape features, including hedgerows and trees	Eco scheme ENVCLIM Sectoral	%UAA	**Annual values** Area under commitment (the total area should be counted even if only a partial payment was made) / total UAA

Note: SO1: ensure a fair income for farmers, SO2: increase competitiveness, SO4: climate change action, SO5: environmental care, SO6: preserve landscapes and biodiversity, SO9: protect food and health quality, SO10: foster knowledge and innovation

Source: Authors

[28] The benefitting person is not necessarily the person receiving the payment (e.g., support for advice is paid to the advisor, while here the number of persons benefitting from the advice is taken into account)

First observations regarding the ability of result indicators to report on the objective of adaptation to climate change (SO4) are the following:

- Result indicator R12, specifically designed to report on the contribution of the CAP to the objective of adaptation to climate change, is generic and does not allow for a sufficiently detailed analysis of the contributions of each intervention in terms of adaptation, nor does it provide an overview of those that have had the most impact.
- Result indicator R5 seems interesting in terms of its potential to assess the deployment of risk management tools in the face of increasing extreme climate events.
- The result indicators are expressed as a percentage of UAA or percentage of farms, which does not necessarily capture the potential of targeted measures that may be very effective.

The new performance, monitoring and evaluation framework (PMEF)[29]

At the European Union level, the new CAP proposes a new framework for monitoring and measuring of CAP results for 2023-27, which has fewer indicators and is streamlined across all areas and funding sources, covering all objectives and which is supposed to allow better measurement of progress in achieving CAP strategic plan targets (tracking of results).

The PMEF foresees greater reliance on EU country notifications and statistics. There are new mandatory indicators (on biodiversity, pesticides and animal health). The integration of specific indicators targeting climate change adaptation issue is not clear yet. A new satellite area monitoring system and more detailed data collection on farming practices should also be introduced.

The first comprehensive data on 2023-27 CAP implementation will be available in 2025. The European Commission must assess the functioning of the new implementation model by Member States and the coherence and combined contribution of interventions in their CSP to meet the European Union's environmental and climate commitments. Where appropriate, the European Commission will make recommendations to Member States to facilitate the fulfilment of these commitments.

[29] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cmef/implementation_en

5. BEST-PRACTICE EXAMPLES OF CONCRETE PROJECTS AND INITIATIVES BY MEMBER STATES TO MITIGATE NEGATIVE EFFECTS OF EXTREME WEATHER EVENTS

KEY FINDINGS

- To address the issue of flooding, Spain promotes in its CSP, for the region of Aragon, the area-specific disadvantages (ASD) intervention, which is one of the only interventions linking together CAP and WFD. It aims to grant compensatory payments to farmers who are affected by flood adjustment measures and will suffer periodic river flooding.
- The Netherland's is addressing the complexity of climate and environmental issues by including in their CSP an innovative eco-scheme promoting systemic responses at the farm level. The Dutch eco-scheme, through a point-based system, encourages farmers to combine different practices into a coherent whole, while ensuring that the rewarded practices are adapted to local specificities.
- Spain and France, among other Member States, are trying to improve their national agricultural insurance system to better address damages caused by climate extreme events. But their effectiveness in preventing economic loss from climate extreme events will have to be examined in the coming years.

This study shows that there are still efforts to be made to better support climate change adaptation of the agricultural sector. The following key challenges were identified:

- A lack of articulation between the CAP and water management policies at River Basin District (RBD) level in Europe, limiting ambitious measures on water management for the agricultural sector under climate extreme events.
- A lack of systemic approaches at the level of agricultural systems, though proven more effective to cope with the increase in extreme weather events caused by climate change.
- A general under-use of risk management tools (insurance, mutual funds) within Member States, and a weak mobilization of CAP measures to support their implementation.

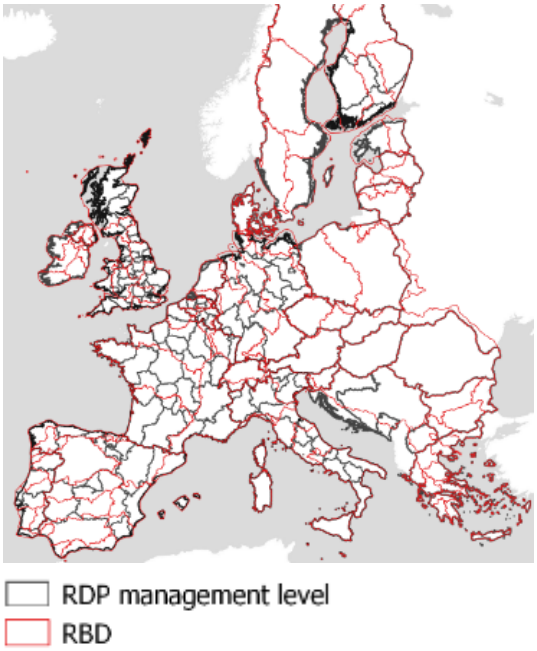
In light of the conclusions reached in the previous chapters, some recommendations are put forward here to improve the effectiveness of the agricultural sector's adaptation to climate change. Examples have been selected to illustrate how some Member States are supporting relevant and/or ambitious solutions that partly address these challenges, in order to promote them for wider adoption, including through the CAP.

5.1. Ensure a better articulation between the Water Framework Directive and the Common Agricultural Policy

As highlighted in section 0,0 synergies between water management, agricultural and climate policies remain limited. Progress needs to be made to strengthen their effective coordination.

In particular, the evaluation of the CAP impact on water (Alliance Environnement, 2019) highlighted that the CAP and the Water Framework Directive (implemented through the RBMPs) are not designed for the same time scale nor designed to be articulated from a geographical point of view, which greatly limits the implementation of targeted CAP measures to address water issues at RBD level. Figure 2 highlights the differences in the management level of programmes resulting from the CAP policy implemented at national/regional level and the Water Framework Directive (at the RBD scale).

Figure 2: Delineation of RDP management level and RBP level in the EU



Source : (Alliance Environnement 2019)

Among the possible measures to strengthen articulation between the CAP and the WFD, the area-specific disadvantages (ASD) intervention (previously called M12 Natura 2000 and WFD) aims to grant compensatory payments to beneficiaries suffering from disadvantages due to specific requirements resulting from the implementation of the WFD, including farmers who are affected by measures planned to deal with floods and who will suffer periodic river flooding. This measure appears very promising to tackle water issues in a context of climate change. However, no Member State plans to implement this measure (in the 18 CSP analysed out of 27), except Spain (ES) in Aragon, where the measure was already implemented in the previous round of CAP programming (2014-2022).

The example below gives more details on how this specific measure is implemented in Spain, in the autonomous community of Aragon, and to what extent it is relevant to relieve farmers from flood damages.

Implementation of the Area-Specific Disadvantages (ASD) intervention in the autonomous community of Aragon in Spain

Figure 3: Ebro River Flood in 2021

Source : (Tella 2021)

In Spain, the Ebro River causes frequent flooding episodes, with severe damage to agriculture and livestock. The latest episode, in December 2021, affected 50 000 hectares of land, including 20 000 ha in Aragon, impacting 14 000 ha of crops. Moreover, the flood also caused the death of livestock.

Under the new CAP programming period, Spain intends to again implement the area-specific disadvantages (ASD) intervention in Aragon to address flood issues. It should be noted that Aragon has implemented this intervention since 2017. Farmers who possess arable land in flood-prone zones of the Ebro River must cultivate, every year until the 30th of September and for 5 years, multi-annual arable crops compatible with regular flooding such as alfalfa, festuca, clover or perennial ray grass. Agronomists created a list of crops chosen for their

ability to withstand several days of submerged soils. Compensatory aid is provided for farmers who have areas of irrigated arable land affected by the Ebro Hydrological Plan, located between the most external flood defence dyke and the river, in a zone of high agro-environmental value (Natura 2000). The compensatory payment for arable zones included in the river basin management plan is a single premium. The amount of aid is EUR 284,25 per hectare on 400 hectares. The calculation of the loss compensation was made in relation to the cultivation of corn and cereals.

Since the implementation of the intervention in 2017, the number of the farmers benefiting from this measure and the surface concerned have been stable. The surface corresponds to almost 100% of the eligible zone. In 2022, 34 farmers applied for the intervention with an average of 11.68 ha (median of 5.24ha) and thus received an average of €3320 (median €1489).

To conclude, even though this measure does not compensate for the damage caused by a flood, it promotes the establishment of crops resistant to flooding, for which less damage is expected. It is a prevention measure rather than an ex-ante one. Compensating for a loss of income by promoting the establishment of crops that are more resilient to extreme events, compared to other crops that are less resilient but more appealing from an economic point of view, is a best practice for adaptation. This could be replicated more widely and also target other types of risks, for instance the risks of drought by promoting drought-resistant species (for example, sorghum, which consumes less water, instead of maize).

5.2. Further promote systemic approaches at the level of agricultural systems

A wide range of practices can limit the impact of adverse climate event and increase the agricultural sector resilience. However, these measures need to be implemented in conjunction, as part of a holistic approach to truly deliver. Instead, in most CSPs, we observe that these measures tend to be proposed on their own, scattered in schemes tackling only one part of the problem.

While eco-schemes were intended to promote more holistic approaches to meeting environmental and climate objectives at farm levels, most Member States have designed eco-schemes where the implementation of one on-farm practice results in one payment, according to a classic system of thresholds to be respected. These "one practice, one payment" interventions do not make it possible to ensure the resilience of the agricultural sector to extreme climate events, through a systemic approach.

However, it is interesting to note the specificity of the Dutch eco-scheme, designed according to a points-based system where individual measures are weighted according to their potential to achieve the targeted objective (be it environmental and/or climatic). In France, among the different ways to access the ecoscheme, the one promoting crop diversification also uses a point system. Such point-based systems are a good starting point to promote more systemic approaches to address climate change adaptation issues at the farm level.

Example of the systemic approach of the Dutch eco-scheme

The Dutch eco-scheme is based on a points system: in order to be eligible for the eco-scheme, a beneficiary must reach a minimum number of points for the goals on climate, soil & air, water, biodiversity and landscape. The points system combines target requirement (objectives/sub-targets) with measure requirement (activity). As regional differences exist, it has been decided to establish a national system, setting out a number of rules, and regional variations that would ensure that

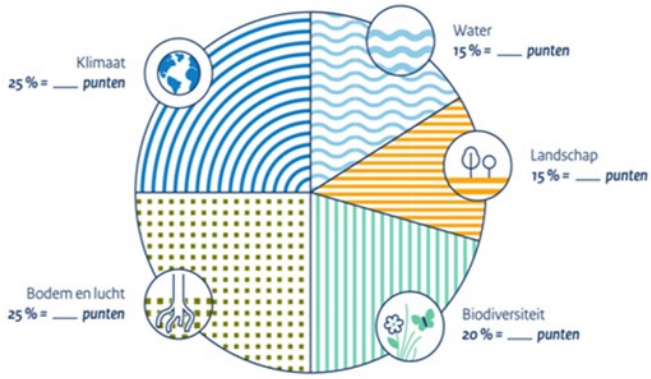
specificities of each region are taken into account in the design of the eco-scheme. Thus, the Netherlands has been divided into 8 regions, each of which falls under a different category (group 1 or 2)[30]. Two groups have been defined according to characteristics and constraints of the region[31].

In order to be eligible for the eco-scheme, farmers must carry out activities that contribute to the five objectives: climate, soil & air, water, biodiversity and landscape. The minimum number of points a farmer should achieve depends on the amount of eligible area he or she manages.

Box 6: Approach to calculate the minimum number of points to be achieved per hectare

	Ratio to apply for regions belonging to:	
Eco-targets	**Group 1**	**Group 2**
Climate	1,5	**1,25**
Soil and air	0,75	**1,25**
Water	0,75	**0,75**
Landscaping	0,5	**0,75**
Biodiversity	**1,5**	**1**

→ These ratios can also be expressed in a "disk of five", as shown below for regions belonging to Group 2.



Example:

If the farm (i) is in a region belonging to group 2 and (ii) is 50 hectares in size, the farmer must, according to the table, obtain the following points in order to be eligible for participation in the eco-scheme:

- Climate: 50 ha *1,25 = 62,50
- Soil & air: 50 ha*1,25 = 62,50
- Water: 50 ha*0.75 = 37,50
- Landscape: 50 ha*0.75 = 37,50
- Biodiversity: 50 ha*1 = 50

Total of points to reach: 250 points (minimum)

Source: Dutch CSP

To reach these points, the farmer must implement sufficient beneficial practices (22 eco-practices are listed in total in the Dutch CSP).

Box 7: Approach to calculate the number of points achieved by implementing a set of different practices (among the 22 practices listed in the Dutch CSP)

For each of the practices, a number of points is allocated by eco-target. An activity does not receive points if the contribution to the goal is null and receives 4 points if the activity has an important

[30] Regions of group 1: Peat colonies, Eastern Beek valleys and extractions, Southern Beek valleys and extractions. Region Group 2: Construction Corner,Highland and Oldambt, Northern Meadow Area, Flevopolders, Western Holland, Southwest Delta and Rivierenland.

[31] It appears that the need for the contribution to the targets differs from region to region. In regions with predominantly clay and peat soil types, the focus is more on soil, air and landscape. In regions with a predominantly sandy soil type, the focus is on climate and biodiversity.

contribution in determining the eco-target. The points in the table below are linked to carrying out the activity on one whole hectare.

	Climate	Soil and Air	Water	Landscape	Biodiversity
Grassland with herb	2	4	1	3	1
Nitrogen-fixing plant	3	2	0	1	1
Permanent ground cover	3	4	4	1	1
Hedge	4	2	0	40	60
Biological control	0	4	2	1	2

Example: if a farmer performs "Grass land with herb" activity on 50 hectares, he or she gets 50 * 2 = 100 points for climate, 50*4 = 200 points for soil & air, 50 * 1 = 50 points for water, 50*3 = 150 points for landscape, 50* 1 = 50 points for biodiversity. The points for all eco-activities carried out on the farm are added, so that there is a point total for each of the goals.

Source: Dutch CSP

After verification of the compliance of the farmer with the eligibility conditions, it shall be assessed whether the value of the activities taken together is sufficient to justify the payment of the subsidy. On the basis of this justification (and field and administrative checks) it is checked on which and how many hectares the management activities have been carried out correctly in the management year. At that time, it is also determined whether changes have taken place, without prejudice to the objective of the scheme. The subsidy amount that a farmer is entitled to is determined by a unit amount per hectare of eligible area managed, that can range from gold (EUR 200€/ha), silver (EUR 100€/ha) to bronze (EUR 60€/ha). This subsidy amount shall be paid when it is shown that the farmer has carried out sufficient activities to justify the subsidy amount.

In the coming years, as the eco-scheme is further developed, the weighting factors for the five eco-targets can be further adapted to reflect the specific context, needs and challenges in these nine regions.

To conclude, the Dutch eco-scheme, through the point system, which is quite innovative, encourages farmers to implement several practices which concurrently contribute to climate and environmental goals. On the one hand, the more farmers implement eco-practices, the greater the subsidies will be. On the other hand, this mechanism seems to be flexible enough to give farmers the freedom to choose the measures that best suit their needs, which may increase their willingness to participate in the mechanism.

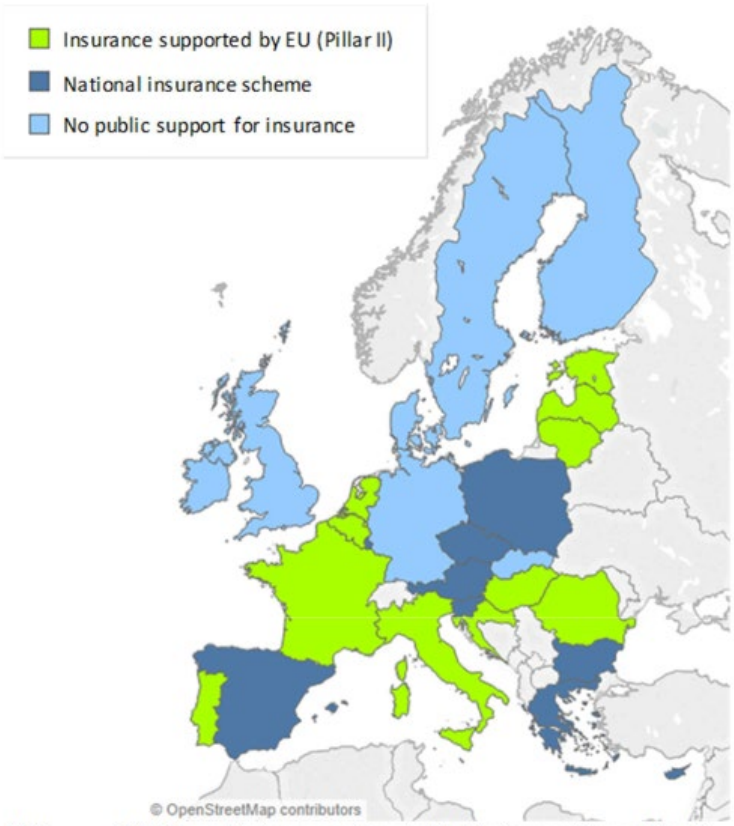
This example highlights that the complexity of climate and environmental issues requires systemic responses. It is obvious that the implementation of a single practice alone cannot enable adaptation to climate change. It is the synergies between different practices that can make farming more resilient to the increase in extreme weather events expected under climate change. Therefore, the point system set up by the Netherlands encourages farmers to combine different practices into a coherent whole, and indeed to be rewarded for doing so, while ensuring that the rewarded practices are adapted to local specificities.

5.3. Further increase the uptake of climate-risks insurance within Member States

The use of risk management tools is one of the main ways to cope with extreme weather events and ensure farm resilience after a disaster. Indeed, protecting farmers' incomes helps sustain agricultural systems after a climate disaster.

However, to date, the uptake rate of insurance by farmers ranges from <5% to >75% and a large number of farmers pay for a mono-risk insurance rather than a multi-risk one. The variation in the uptake of crop insurance across Member States can be partly explained by the low availability of public support. Indeed, the analysis of the previous CAP (2014-2022) underlines an under-use of measures to support risk management tools (M5, M17), that have been infrequently programmed, or that have had a low uptake within Member States (Alliance Environnement 2018) . In total, 90% of farmers subscribing to an insurance are covered without EU aid (European Commission 2017). Other instruments (such as mutual funds and income stabilization tool), to prevent, mitigate or cope with climate risks, are still largely unavailable in the EU.

Figure 4: Map of insurance supports in the EU, during the period covered by the previous CAP



Note: Little EU support for insurance exists under Pillar I for Germany, Cyprus and Slovakia.

Source: (European Court of Auditors. 2019)

The current study, targeting the new CAP programming, has also shown that relatively few measures are oriented towards supporting the deployment of these risk management tools. To date, for Member States mobilizing CAP funding to help farmers take out insurance, these funds are mainly used to subsidize premiums, but without conditionality constraints. The CAP encourages Member States to review their insurance systems to better cover the agricultural sector in the face of climatic disasters. But the design of insurance systems is the responsibility of the Member States, and the insurance companies themselves.

But it should be highlighted that, even if some Member States do not intend to use CAP funds to help farmers subscribe to insurance, some of them have already robust insurance mechanisms supported by the State outside CAP funds. This is the case, for example, of Spain, which has one of the most elaborate insurance systems against natural risks (including climate risks) within the EU.

Below are presented the Spanish Combined Agricultural Insurance System (SSAC), which is one of the most elaborated insurance schemes in the EU against natural risks (including climate risks). It does not mobilize CAP funds but has inspired the architecture of new insurance schemes in other member states

(e.g., France). The new French insurance system based on the National Solidarity Fund, planned for 2023, is also presented here as an example. Subsidized by CAP funds, it aims to better cover the negative effects of climate change.

The Spanish Combined Agricultural Insurance System (SSAC)

The high volatility of Spanish agricultural incomes, especially due to production risks (linked to climatic and biological hazards), has led to the development since 1978 of the Spanish Combined Agricultural Insurance System (SSAC), created by Law 87/1978. It is one of the most elaborate insurance mechanisms within the EU (Agroseguro 2022) against natural risks (including climate risks from many hazards: drought, fire, flood, frost, hail, rain, snow and violent winds).

It has been designed to promote the purchase of agricultural insurance by producers (i) through the development of an increasing number of insurance lines, and (ii) through the subsidy of premiums and their public reinsurance through the Insurance Compensation Consortium.

The combined agricultural insurance subscription is voluntary, although it is incentivised by public subsidies which reduce the cost of premiums to producers. The system is built on institutional arrangements between both public and private actors:

(i) The State[32] and regional government partially covers the costs of the premium that farmers have to pay to private insurance companies (between 20% and 60%) (Madre et Devuyst 2016) and reinsure the insurers (through the Insurance Compensation Consortium).

(ii) The private actors include, on the one hand, the farmers grouped in "entidad mutuales" or agricultural professional organizations and cooperatives, who are greatly involved in the management of the system, and, on the other hand, the insurance companies, grouped in a pool called Agroseguro.

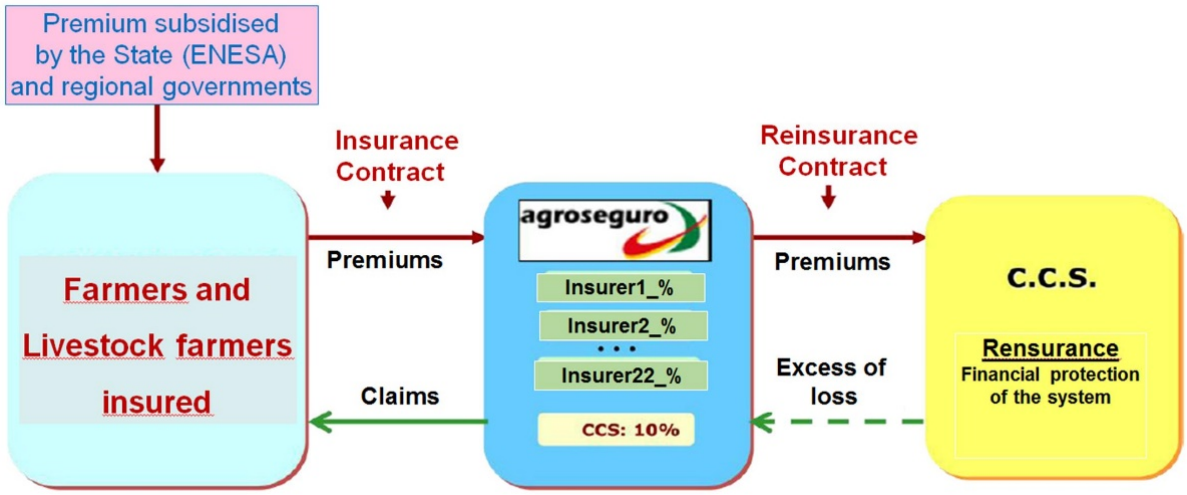
Grouping all insurance companies into a single pool has several advantages:

(i) On the one hand, a price is fixed for each insurance policy and competition between insurers is limited to customer services.

(ii) On the other hand, Agroseguro manages the public subsidy: the farmer pays only the part of the premium which applies to him, and Agroseguro requests the amount of the subsidy which completes the total cost of the insurance to the State and the autonomous communities.

[32] Through the State Agricultural Insurance Entity (ENESA, of the Ministry of Agriculture, Fisheries and Food) and the General Directorate of Insurance and Pension Funds (DGSFP) and the Insurance Compensation Consortium (CCS), both of the Ministry of Economic Affairs and Digital Transformation.

Figure 5: Operating principles of the Spanish Combined Agricultural Insurance System (SSAC)



Source: (CCS 2022)

Although Spain does not intend to use EU CAP funds to subsidise its insurance system, it states in its CSP that it will continue to rely on the National Agricultural Insurance Plan as the main tool for climate risk management for the period 2023-2027, complemented by specific crisis management measures targeting certain sectors, in application of the Common Organisation of Agricultural Markets. "It is a system consistent with the characteristics of the risk management tools promoted by the CAP. For example, it provides for a minimum threshold for the recovery of claims, establishing minimum indemnifiable and absolute indemnities above 20% in most policies. Likewise, it respects the principle of "no overcompensation" since the guaranteed capital is limited to a variable proportion of the insurable production. In addition, the insurance subsidy includes measures to modulate public support according to the size of the beneficiaries, with the aim of giving favourable treatment to the recruitment of small farms, as they are the most likely to suffer annual losses of more than 30% compared to the average of the previous three years." (extSpain CSP)

The large volume of annual production insured in Spain and the farms covered by the insurance system contribute to minimizing the risks of extreme climatic events. The number of insurable crops covered has been expanding consistently in the past decades. In 2019, 78% of fruit crop areas are insured, 46% for vegetable areas, 39% for viticulture and more than 75% of winter cereal areas (Koenig et al. 2022).

Moreover, the financing of insurance through national budgets will allow more CAP funds to be devoted to complementary rural development interventions, targeting adaptation solutions related to climate change prevention and preparedness (while taking out insurance is a recovery strategy).

The new French insurance system based on the National Solidarity Fund planned for 2023

Challenges of the previous system

France had a crop insurance, which, despite part of the insurance premium being covered since 2005 by the State, has so far had only limited success with farmers. Indeed, the proposed contracts of the previous insurance system were not attractive to farmers. Because of the low number of uptakes the system struggled to mutualize costs and were too expensive for insurers and farmers . The main weaknesses were the following (Jan 2023):

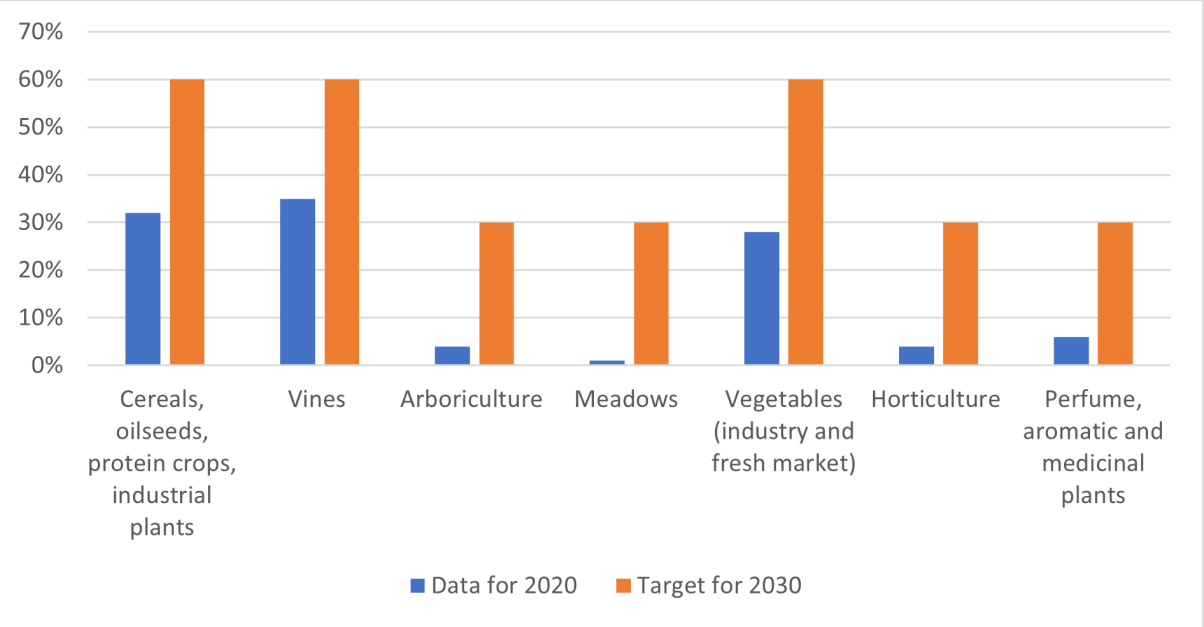
- The crop insurance, subsidized at 65%, was only triggered after 30% of losses, a threshold considered too high by farmers.
- The reference yield used as a basis for comparison with the yield obtained during the climatic hazard was based on the Olympic average of the last five years (the average of the three remaining years once the best and the worst are removed), which tends to decrease with the accumulation of bad years and does not necessarily reflect the agronomic potential of the farm.
- The "calamity" fund provided better compensation than insurance for the uninsured.
- The contracts had some important exclusions, for example, they did not compensate for loss of quality or damage due to disease or insects.
- The unannounced drop in subsidy rates in 2013, which led to a loss of farmers' confidence in the system.

While one third of cereal surfaces are insured today, only 3% of orchards and 1% of meadows are insured (Jan 2023). The low proportion of insured orchard and grassland surfaces is explained by the fact that before the reform, the losses of these productions were still compensable under the agricultural calamity regime, making crop insurance unattractive, whereas field crops were made ineligible for the calamity regime in 2009.

Presentation of the new system

A reform was thus undertaken in 2019 to improve the attractiveness of the crop insurance, by addressing weaknesses of the previous one, in order to increase its uptake among farmers. The reform aims to increase the share of area covered by insurance. Objectives targeted for 2030 are presented below:

Figure 6: Percentage of surfaces insured by an insurance contract.



Source : (Jan 2023)

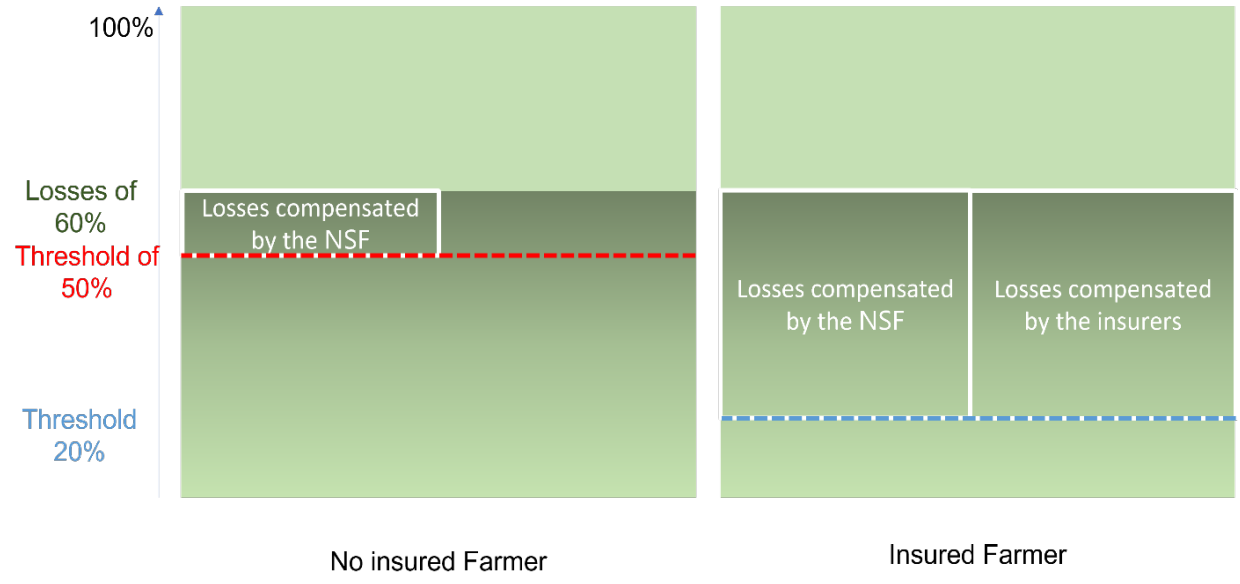
Since the law of March 2nd 2022, there is a single universal compensation scheme for crop losses in France. This is based on national solidarity and the sharing of risk between the State, farmers and insurers. Farmers can choose not to insure. In this case, they will be reimbursed by the National Solidarity Fund (NSF), only if the disaster generates at least 50% of losses (30% for arboriculture and grassland) and they will be compensated up to 45% of losses that exceed the threshold. For farmers who have chosen to be insured, they will be reimbursed as soon as the claim exceeds the chosen deductible or threshold (from 15%) and will be compensated for 100% of the losses that exceed the deductible. Part of the compensation of insured farmers is provided by the NSF. In all cases, the insurer is positioned as the single point of contact for farmers to receive compensation, whether they are insured or not.

In the French CSP, the intervention "Payment of insurance premiums" supports aid granted in the form of partial payment of the contribution or premium for multi-risk climate insurance (hereinafter 'harvest insurance') taken out by a farmer in order to cover himself against the consequences of climatic events on his production (drought, excesses of temperature and heatstroke, sunburn, lack of solar radiation, low temperatures, cold snaps and frosts, hail, excess water, heavy rain, excess humidity, the weight of snow or frost which would cause the rods to bend or break, etc.). The subsidy rate is defined up to a limit of 70 % of the contribution or grantable premium with a threshold between 20 % and 50 % of yield losses compared to the historical yield.

In other words:

- The losses lower than 20% are borne by the farmers
- The losses between 20 to 50% are covered by the insurers
- The losses over 50% are compensated by the NSF

Figure 7: Example in the case of a damage causing a loss of 60% of the harvest for the reimbursement of an uninsured and insured farmer for a threshold at 20%



Source : (Réforme de l'assurance récoltes 2022)

Like the Spanish system, in order to guarantee fair prices for insurance premiums, the French State plans to set up a pool of insurers in order to bring together all the data useful for the definition of insurance contracts, particularly in terms of damages. Nevertheless, progress is needed on

transparency to convince farmers that the premiums are calculated on the basis of reliable indicators. Moreover, new technical tools are developed to measure damages, such as the satellite index for the forage areas.

To achieve these objectives, the French global public budget allocated to the implementation of this insurance system during the 7 next years is between EUR 600 and 700 million (Varenne agricole de l'eau et de l'adaptation au changement climatique 2022).

It is expected that by increasing the area and the diversity of insured productions, this will contribute to minimizing the economic damage caused by extreme weather events. However, the subscription to the insurance is not conditional to the adoption of adaptive practices, such as the implementation of protective measures (e.g., hedges and shade trees), the reduction of the size of agricultural plots or crop diversification. This might encourage farmers to further specialise or choose inappropriate or high-risk crops, which would in turn reduce farms' resilience (Midler et Pagnon 2022). Since it is a new instrument, its effectiveness regarding prevention of economic losses from climate extreme events will have to be examined in the coming years.

Limits of the use of insurance systems

The crowding out of *ex ante* private risk management measures (such as adaptation practices falling under prevention and preparedness) is highly likely when *ex post* public measures dominate (for instance subsidies of insurance premium) (Bagnarosa, Cordier, et Gohin 2021). In the same way, the implementation of insurance systems can lead to a change in the behavior of the farmer who can take more risks. To reduce these risks, it is possible to modulate the level of premiums according to the adaptation practices implemented by the farmer and the diversification of productions. But this modulation can only be managed by the insurances companies themselves.

It should also be kept in mind that a farmer will be more likely to take out insurance if he has suffered an extreme weather event the previous year. Thus, due to the expected increased frequency of extreme climatic events in the coming years, any increase in the number of insured persons will not be solely due to the implementation of new insurance systems.

Finally, if the volatility of agricultural production and income increase with the increase of extreme climate events, the subscription to insurance contracts could become more expensive and less efficient for farmers and for insurers.

6. CONCLUSIONS

Climate extremes are increasing across Europe with pronounced regional differences. Northern Europe and mountainous regions will likely see more heavy precipitation extremes, while Southern Europe will be faced with severe drought and temperature extremes. Central Europe will endure both heat extremes and an increase in heavy precipitation. Drought and extreme heat have caused by far the largest share of negative economic impacts to European agriculture, and this is forecast to continue into the future.

These climate extremes will have varying impacts depending on the sub-sector considered. Productions vulnerable to climate extremes include maize (heat), tubers (flooding) and soybean (high yield variability). The majority of crops will suffer heavy yield damage in case of drought, except where irrigation persists. Grassland is susceptible to drought, causing cascading impacts on the livestock sector.

To date, several complementary solutions exist to help farmers prevent, mitigate or cope with climate risks.

While the previous CAP seems to have had limited effects on supporting both preventive measures and risk management schemes (Alliance Environnement 2018), the new CAP reform is a major turning point promoting policy instruments for supporting the sector to proactively mitigate the effects of extreme weather events caused by climate change.

To this end, instruments most promoted by Member States in their CSP to respond to the challenges of adaptation are essentially direct payments (through eco-schemes), sectoral interventions, ENVCLIM interventions and INVEST interventions. However, it remains difficult to assess whether these measures have been designed in a holistic way, by linking them together within each CSP. On the other hand, it is clear that interventions to promote adaptation to climate change generally support single practices ("1 practice = 1 payment"), which generally does not allow for ambitious paradigm shifts.

Finally, while some countries plan to adopt new approaches in the development of risk management tools, the relatively weak mobilization of the CAP to support their deployment should be underlined. To date, risk management tools are very rarely cited as instruments that specifically address adaptation of the agricultural sector to climate change (SO4). Rather, they are seen as tools to increase the overall resilience of the agricultural sector (SO1).

7. RECOMMENDATIONS

This study provides an ex-ante assessment of how Member States plan to deploy measures targeting climate change adaptation issues. It does not aim to anticipate the potential impact of the implementation of these measures on the effective resilience of the agricultural sector in the face of increasing extreme climate events under climate change. Therefore, in the coming years **it will be crucial to analyse which instruments have been effectively mobilized by farmers, and to assess the concrete impacts of their implementation on the resilience of the agricultural sector in the EU.**

Concerning this last point, the adaptation objectives of each Member State, addressing their adaptation needs, remain largely generic with no results-oriented indicators. However, to assess the real contribution of the new CAP to the adaptation of agriculture to climate change, the **objectives set by the Member States must be results-based**. Indeed, only results-oriented objectives can truly encourage the design of relevant measures with a view on promoting systemic approaches. It will therefore be important to **analyse the ability of the Performance Monitoring and Evaluation Framework (PMEF)** (CMEF s. d.)**, applicable for the CAP from 2023 until 2027, to properly assess the contributions of individual CSPs to the overall objective of adapting the European agricultural sector to climate change**.

As highlighted in the study, climate change is a systemic challenge. Therefore, adaptation to climate extreme events at farm level, but also at sectoral level, requires the implementation of a systemic approach. However, CAP interventions generally support single practices, which does not allow for ambitious paradigm shifts. Several models (Lampkin et al. 2020) could have been developed to promote the use of a bundle of related management measures to enhance the delivery of the specific objective, instead of attempting to achieve specific objectives with individual measures. For example**, for eco-schemes, point-based, result-oriented, and system-based approaches could have been more comprehensively developed in the CSPs, to ensure more ambitious interventions**.

The current study also showed that the uptake rate of insurance by farmers ranges from <5% to >75% and can be partly explained by the low availability of public support. **Hence, more efforts should be made to support the deployment of risk management tools.** However, it is also important to ensure that support for insurance schemes does not become the main risk management tool, as it is an ex-post measure (supporting recovery from an adverse climate event) that should not take overshadow the implementation of ex-ante measures (promoting prevention, preparedness and response) at the farm level.

Finally, synergies between water management policies, agricultural policies and climate policies still need to be strengthened, notably through a better integration of flood risk management and drought risk management into CAP strategic plans. Also, solutions stimulating local adaptation, nature-based solutions, sustainable uses and resilience of freshwater resources, are relevant for the agricultural sector. To this end, financial support for adaptation in the agricultural sector should be increased through the European Structural and Investment Funds, the Common Agricultural Policy (investments, eco-regimes and advisory services) and the LIFE programme.

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ANNEX A. GLOSSARY OF EXTREME EVENTS

Glossary name	Definition
Climate extreme	The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., high temperature, drought, or heavy rainfall over a season).
Extreme weather event	An event that is rare at a particular place and time of year. Definitions of 'rare' vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense.
Heatwave	A period of abnormally hot weather, often defined with reference to a relative temperature threshold, lasting from two days to months. Heatwaves and warm spells have various and, in some cases, overlapping definitions.
Drought	An exceptional period of water shortage for existing ecosystems and the human population (due to low rainfall, high temperature, and/or wind).
Agricultural and ecological drought	Depending on the affected biome: a period with abnormal soil moisture deficit, which results from combined shortage of precipitation and excess evapotraCSPiration, and during the growing season impinges on crop production or ecosystem function in general.
Hydrological drought	A period with large runoff and water deficits in rivers, lakes and reservoirs.
Meteorological drought	A period with an abnormal precipitation deficit.
Cold spell	A period of abnormally cold weather, often defined with reference to a relative temperature threshold, lasting from two days to months.
Frost	A weather condition or period of cold weather in which a deposit of small white ice crystals formed on the ground or other surfaces when the temperature falls below freezing
Flood	The overflowing of the normal confines of a stream or other water body, or the accumulation of water over areas that are not normally submerged. Floods can be caused by unusually heavy rain, for example during storms and cyclones.
Extreme/heavy precipitation event	An extreme/heavy precipitation event is an event that is of very high magnitude with a very rare occurrence at a particular place. Types of extreme precipitation may vary depending on its duration (hourly, daily, or multi-days (e.g., 5 days)) though all of them qualitatively represent high magnitude. The intensity of such events may be defined with a block maxima approach such as annual maxima or with a peak over threshold approach, such as rainfall above the 95th or 99th percentile at a particular place.
Hail	Pellets of frozen rain which fall in showers from cumulonimbus clouds
Landslide	A collapse of a mass of earth or rock from a mountain or cliff
Fire weather/Wildfire	Weather conditions conducive to triggering and sustaining wildfires, usually based on a set of indicators and combinations of indicators including temperature, soil moisture, humidity, and wind. Fire weather does not include the presence or absence of fuel load.
Storm surge/ Coastal storm	The temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place.

Source: Authors

ANNEX B. RECORD OF RECENT EXTREME EVENTS IN EUROPE

2022	Compound drought & heatwave	WCE	Western Central Europe faced water shortages, extreme heat, and soil moisture drought conditions throughout the summer of 2022
2022	Heatwave	NEU	Exceptional heatwave affected large parts of the UK. It was the first time that temperatures of 40°C and above have been forecast in the UK.
2021	Extreme rainfall	WCE	Heavy rainfall associated with cut-off low-pressure system "Bernd" led to severe flooding particularly in the German states North Rhine-Westphalia and Rhineland-Palatinate, as well as in Luxembourg, and along the river Meuse and some of its tributaries in Belgium and the Netherlands.
2021	Cold spell	WCE	Human-induced climate change was detected to play a role in the cold early April following a very warm March 2021 that led to large scale frost damages in grapevines and fruit trees in central France.
2021	Heatwave	WCE	Extreme temperature in France
2020	Heatwave	WCE	Extreme temperature in France in Belgium
2019	Heatwave	WCE & NEU	After the extreme heat that took place in the last week of June 2019, a second record-breaking heat wave struck Western Europe and Scandinavia at the end of July 2019.
2019	Heatwave	WCE, SEU, EEU	A heatwave struck large parts of Europe during the last week of June 2019, breaking several historical records at single locations in France, Switzerland, Austria, Germany, the Czech Republic and Spain.
2018	Heatwave	NEU	The summer of 2018 has been remarkable in northern Europe. A very persistent high-pressure anomaly over Scandinavia caused high temperature anomalies and drought there from May to July.
2018	Storm	WCE	2018 began with a series of four strong wind storms over Western Europe. In particular, two major events pounded the continent: Storm Eleanor on January 3, and Storm Friederike on January 18.
2017	Heatwave	SEU, WCE	2017 summer in Western Europe and the Euro-Mediterranean region has been remarkable in several aspects. Early summer heat during much of June affected western European countries (in particular, France, Switzerland, Belgium, the Netherlands, England, Portugal and Spain).
2017	Compound heatwave & Wildfires	WCE	June 2017 was marked by high temperatures across Western Europe, with heatwaves triggering national heat-health plans and wildfires requiring evacuations in Portugal and Spain.
2017	Cold spell	EEU, SEU	Severe winter weather struck southeastern Europe, with extreme cold and snow in Italy, the Balkans and Turkey. This caused many accidents on roads, school closures, and cancelled flights. The Danube river and Bosporus sea strait were closed for shipping.

2016	Extreme rainfall	WCE	Torrential rainfall ravaged parts of central and northeastern France and southern Germany, forcing the evacuation of thousands.
2015	Compound extreme rainfall & wind/Storm	NEU	A fierce Atlantic storm, Desmond, struck parts of northern England, southern Scotland and Ireland the first weekend in December 2015, with a new national record for rainfall accumulation in a 24-hour period.
2015	Heatwave	NEU, WCE, EEU,SEU	A heatwave stretched across much of Europe in early July, and was assessed by a team of scientist to be more likely to happen now than in the past due to climate change.
2010	Compound heavy rain, flood and landslide	WCE	Heavy rains and landslide in France, Germany and Czechia.
2007	Compound heatwave & drought	SEU & EEU	Extreme hot temperature and droughts across Southern Europe (Greece, Bulgaria, Romania, Italy)
2006	Heatwave	WCE, SEU	Extreme hot temperature across Western and Southern Europe
2005	Compound extreme rainfall & landslide	WCE, EEU	Heavy rains and landslide in northern France, Belgium. Similar event in Bulgaria and Romania
2003	Compound heatwave & drought	WCE, SEU	Extreme hot temperature and droughts across Western and Southern Europe

Source: Authors

ANNEX C. KEYWORDS FOR THE SCREENING OF THE PRACTICES SUPPORTED BY THE CSP

Increased risks of floods

- flood
- drain
- grazing pressure
- LU
- Density / densities
- Soil structure
- Cover
- Rotation
- Organic matter / material
- Reservoir
- Rainfall / Rainwater
- Hedge
- Buffer

Increased risks of drought and water scarcity

- Irrigation
- Water use
- Trickle
- Soil moisture
- Conservation agriculture
- Tillage
- Soil compaction
- Cropping pattern
- Crop calendar
- Resilient
- Resistant
- Diversification
- Rotation
- Heat / heat tolerant
- Shelter
- Pasture management / grazing management
- Banks / fodder banks

Increased risks of frost, hail and storms

- Frost
- Heater
- Sprinkler
- Wind machine
- Hail
- Greenhouse
- Agroforestry
- Hedge
- Buffer
- Tree shelter

Increased risks of extreme weather events as a whole

- Adaptation plan
- Contingency plan
- Warning system
- Advice
- Insurance
- Mutual fund
- Precision
- Diversification (activity)

ANNEX D. ANALYSIS OF THE NATIONAL STRATEGIC PLAN BY COUNTRY

CAP Strategic Plan (CSP) of Austria (AT)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
B14 - increasing resilience and Adaptation to climate change	1	3		1		1			
B17 - Preservation and expansion of climate-friendly and site-adapted animal husbandry	1	1		1		1			

Other needs, out of the SO4, related to **climate change adaptation:**

- B19 - Qualitative preservation and improvement of the condition of soil or soil fertility
- B20 - Quantitative conservation of soil as a basis of production
- B45 - Improving knowledge and efficient use of resources, biodiversity and climate change

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change): /

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures	1	2	
	Improve soil structure to increase water retention capacity and improve drainage	3	4	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers		2	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity		2	
	Better manage crop water demand			
	Improve crop diversification and rotation	2	2	
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production	1	3	
	Find alternatives for supplemental feeding			
	Active protection against frost			

Increased risks of frost, hail and storms	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design		2	
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- No risk management tool supported by the CAP
- No COOP or KNOW intervention to meet the SO4
- 1 intervention specific to the fruit and vegetables sector to meet the SO4
- The Eco schemes identified to meet the SO4 are well linked to adaptation practices –
- In particular, many measures in favor of the soil
- The Envclim interventions are less identified to meet the SO4

CAP Strategic Plan (CSP) of Belgium-Wallonia (BE-WA)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
4.14 - Increasing the resilience of farms and forests to climate change	2	3	1	2		3		1	

Other needs, out of the SO4, related to **climate change adaptation:**

- 5.11 Creating the framework conditions for the transition of agricultural and forestry holdings
- 5.12 Preserving the productive potential/fertility of soils

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- Le Plan Sophia
- Le programme TRANSAÉ
- Le projet « soutenir la transition environnementale - Plan d'actions Agroécologie » du plan de relance wallon
- Arrêté du Gouvernement wallon sur les plantations, avec son objectif de plantation de 4000 km de haies et/ou d'un million d'arbres

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods (Main climatic causes of risk : Increase of extreme events frequency ; Loss of soil water retention capacity)	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures	1	2	
	Improve soil structure to increase water retention capacity and improve drainage	2	2	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	1		
Increased risks of drought and water scarcity (Main climatic causes of risk : Decreased annual and/ or seasonal precipitation ; Increase in the frequency of extreme conditions (droughts and heat waves))	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity	1		
	Better manage crop water demand	1		
	Improve crop diversification and rotation	2	2	
	Introduction of more heat tolerant species/breeds	1		
	Increase shelter for animals			

	Improve pasture and grazing management to match stocking densities to forage production	1	1	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design	1		
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- Sectoral interventions to adapt to climate change for Beekeeping products and fruit and vegetables
- No risk management tools supported by the CAP
- The Eco schemes identified to meet the SO4 support adaptation practices except the intervention "144 – eco-schemes – Reduction of inputs"
- An Eco-scheme support crops that are more drought-resistant (quinoa, buckwheat, sorghum, etc.: 142 – eco-schemes – environmentally-friendly crops
- Few interventions against risks of frost, hail and storms (practices supported in the sectorial interventions or invest)

CAP Strategic Plan (CSP) of Croatia (HR)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
07- Improve practices that contribute to climate change adaptation and mitigation	1	6	2	4					

Other needs, out of the SO4, related to **climate change adaptation:**

- 02- Make more and more efficient use of risk management tools

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- Disaster Risk Management Strategy for 2030 and Disaster Risk Management Action Plan 2021 By 2024, for the implementation of the Disaster Risk Management Strategy for 2030
- The Strategy for Adaptation to Climate Change in the Republic of Croatia for the period up to 2040 with a view to the year 2070 and the Action Plan for the implementation of the Strategy for Climate Change Adaptation in the Republic of Croatia for the period up to 2040 with a view to the year 2070
- The integrated national energy and climate plan for the Republic of Croatia for the period 2021-2030

Adaptation solutions promoted

		CSP measures that promote/support the implementation of identified adaptation practices		
Risks related to extreme weather events (and main climatic causes)	**Adaptation solutions**	PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures	2	2	
	Improve soil structure to increase water retention capacity and improve drainage	4	1	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	1	1	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity	1		
	Better manage crop water demand	1		
	Improve crop diversification and rotation	2	1	
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production	2	1	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design	1	1	

Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			1
	Other risk management tools			
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- A single need identified to meet the SO4 but almost all the recommended practices are supported by interventions that meet this need
- No INVEST, RISK, COOP, KNOW interventions which meet SO4
- Only the interventions in favor of the conservation of landscape elements (hedges, buffer) have not been identified as meeting the needs of SO4
- There is one intervention for agricultural insurance supported by the CAP, but it has not been identified to meet the SO4

CAP Strategic Plan (CSP) of Denmark (DK)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
D1- Promote climate-friendly agricultural production	1	4		1	1	3			
D2- Expansion of the forest area to mitigate climate impact.	2					1			
D3- Increase incentives for climate-related investments.	1	1	4			2			

Other needs, out of the SO4, related to **climate change adaptation:**

- A6 Risk management instruments are more at stake to counter threats and crises.
- E2 Securing groundwater and surface water
- E5 Reduce pressure on natural resources from the large agricultural area.
- E6 Tackling soil erosion can address threats posed by climate change.

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- River basin management plans and Natura 2000 plans
- Nature and Biodiversity Package

Adaptation solutions promoted

		CSP measures that promote/support the implementation of identified adaptation practices		
Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures		1	
	Improve soil structure to increase water retention capacity and improve drainage	5	2	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers			
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity			
	Better manage crop water demand			
	Improve crop diversification and rotation	3	1	
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production		2	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design			

Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations	1		
	Farm activity and production diversification			

Main observations

- No interventions to maintain landscape features
- Nothing against risks of frost, hail, and storms
- No insurance system supported by the CAP
- Interventions for and Fruit/vegetable to adapt to climate change
- The Eco scheme interventions are well identified to meet the SO4

CAP Strategic Plan (CSP) of Estonia (EE)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
V4.1 - Increase awareness of the mutual impact of climate, its changes and agriculture	1					3			
V4.5 - To promote land improvement investments mitigating weather risks	3								2
V4.6 - Ensure adaptation to climate change in crop production	1					3			
V4.1 - Increase awareness of the mutual impact of climate, its changes and agriculture	2			1					

Other needs, out of the SO4, related to **climate change adaptation:**

- V5.6 - Maintenance of soil fertility
- V6.6 Promote water bodies sustainable agricultural practices

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- 2030 National Energy and Climate Plan

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures		3	
	Improve soil structure to increase water retention capacity and improve drainage	2	1	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	2	1	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity		1	
	Better manage crop water demand			
	Improve crop diversification and rotation	2		
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals		1	
	Improve pasture and grazing management to match stocking densities to forage production		2	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			

	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design	2	1	
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			1
	Other risk management tools			
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- No eco-scheme to meet the SO4 needs. However, the eco-scheme interventions support many CC adaptation solutions
- There is an animal welfare shelter intervention for the heat
- An insurance system is supported by the CAP
- The only ENVCLIM measure meeting the needs of SO4 does not correspond directly to the adaptation practices identified since it is "Support for growing local plants" with no link to adaptation to CC in the description

CAP Strategic Plan (CSP) of Finland (FI)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II –INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
Beta 08 - Taking climate and environmental impacts into account, promoting resource efficiency and the circular economy	3					4		1	
Beta 09 - Promoting adaptation to the impacts of climate change	1	1		11		2		1	

Other needs, out of the SO4, related to **climate change adaptation: /**

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- National Energy and Climate Strategy and the Climate Law
- The medium-term climate plan, KAISU
- The Climate Plan for the Land Use Sector
- The National Climate Change Adaptation Plan 2022 and the MFA's Climate Change Adaptation Operational Program are the basis for action on adaptation to climate change in agriculture.

Adaptation solutions promoted

		CSP measures that promote/support the implementation of identified adaptation practices		
Risks related to extreme weather events (and main climatic causes)	**Adaptation solutions**	PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage		1	
	Reduce grazing pressures			
	Improve soil structure to increase water retention capacity and improve drainage	1	7	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	3	1	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency		1	
	Improve soil moisture retention capacity			
	Better manage crop water demand			
	Improve crop diversification and rotation			
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production		1	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			

	Landscape design	3	2	
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan		1	
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice		1	
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations		1	
	Farm activity and production diversification			

Main observations

- No intervention supporting insurance systems or other risk management tools
- No sectorial intervention to meet the SO4
- Various eco schemes are not identified as meeting the SO4 while supporting an adaptation practice (except "winter vegetation cover")
- Many KNOW and COOP interventions are in favor of the climate and its adaptation
- Many interventions to improve the soil structure
- Not very concrete intervention for hedge/buffer
- Many measures that are environment-oriented (preservation, soil, water) in Envclim

CAP Strategic Plan (CSP) of France (FR)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
D7 - Make systems more resilient (adaptation: prevention/ management)	1	1	4			2	2		
D2 - Support global levers (beyond climate issues)	1	1		6		2			

Other needs, out of the SO4, related to **climate change adaptation:**

- A6 - Strengthening risk prevention and management to promote the resilience of operations
- I4 - Reinforce the consideration of health risks, in particular related to climate change

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- Plan Climat 2017
- Plan d'action climat du ministère de l'Agriculture et de l'Alimentation (2021)
- Plan national intégré énergie climat (2020)
- Plan national d'adaptation au changement climatique (PNACC 2)

Adaptation solution promoted

		CSP measures that promote/support the implementation of identified adaptation practices		
Risks related to extreme weather events	Adaptation solutions	PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures		1	
	Improve soil structure to increase water retention capacity and improve drainage	1	2	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	1	1	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency		2	
	Improve soil moisture retention capacity			
	Better manage crop water demand			
	Improve crop diversification and rotation	1		
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production		1	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			

	Landscape design	1	1	
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			1
	Other risk management tools			1
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- Eco scheme built to support virtuous systems in general (3 ways to access payments) and contain a hedge bonus
- Eco scheme completed by ENVCLIM interventions which support organic agriculture
- The Envclim interventions (more specifically) MAEC include 2 measures which specifically target more efficient irrigation in field crops and perennial crops. These interventions are supplemented by INVEST measures for irrigation.
- The Envclim interventions not directly labelled as contributing to climate change adaptation needs (D7)
- The Envclim interventions contain an intervention specifically aimed at fodder self-sufficiency on farms
- Interventions for specific sectors to adapt to climate change : wine, olives, fruit and vegetables, cattle
- General insurance and mutual fund system are supported by the CSP but are not directly identified to achieve the SO4

CAP Strategic Plan (CSP) of Germany (DE)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
D.3 Adaptation of agriculture and forestry to climate change	1	2	3	2					
D.7 Flood protection, coastal protection and natural water retention improvement	1			1		1			

Other needs, out of the SO4, related to **climate change adaptation:**

- E.3 Soil protection and reduction of land take
- E.5 Reduction of water consumption with regard to the soil and landscape water balance
- E.6 Extension of sustainable cultivation of protein crops

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- The Climate Protection Act
- The 2030 National Climate action program

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures	1	2	
	Improve soil structure to increase water retention capacity and improve drainage	1	4	
	Increase rainfall interception capacity		1	
	Introduce contoured hedgerows and buffers		4	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity		2	
	Better manage crop water demand			
	Improve crop diversification and rotation	1	3	
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production	2		
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			

	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)	1		
	Landscape design		4	
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			1
	Other risk management tools			
	Use of precision farming: tillage and timing of operations		1	
	Farm activity and production diversification			

Main observations

- No COOP or KNOW intervention to meet the needs identified in the SO4
- The RISK MANAGMENT TOOLS intervention in connection with insurance systems is not identified as meeting the identified SO4 needs either.
- An intervention linked to the specific adaptation of the hop culture
- A special intervention for agroforestry systems in the Eco scheme
- Eco-scheme interventions are well identified to respond to SO4 except: "DZ-0404 — Extensification of the entire permanent grassland of the holding" and "DZ-0405 — Result-oriented extensive management of permanent grassland with at least four regional characteristics"
- Few interventions against risks of frost, hail and storms but they exist among sectoral interventions (fruit and vegetables)

CAP Strategic Plan (CSP) of Greece (EL)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
IF 035.04.02 - Redesign policy on adaptation of agriculture and forestry to climate change	1	4		3		3			
IF 055.04.03 - Information-training and advice on mitigation-adaptation actions (AKIS)	3		3						2

Other needs, out of the SO4, related to **climate change adaptation:**

- IF 018.05.01 - Tackling the impact on agriculture and forestry of floods and droughts
- IF 062.03.06 - Adaptation measures to address the impacts of climate change
- IF 071.06.07 - Increase in retained landscape elements in agricultural land
- IF 073.05.04 - Integrating measures of revised Slap & national climate change adaptation strategy
- IF 082.05.05 - Focus on reducing irrigation losses

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- National Energy and Climate Plan (NECP)
- National Climate Change Adjustment Strategy (NCPKA)
- National Strategy for Climate Adaptation and Regional Climate Change Adaptation Plans (PERSPKA)

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage	1		
	Reduce grazing pressures	1		
	Improve soil structure to increase water retention capacity and improve drainage	3	1	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	1		
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency	1		
	Improve soil moisture retention capacity			
	Better manage crop water demand	1		
	Improve crop diversification and rotation	1		
	Introduction of more heat tolerant species/breeds	1		
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production	1		
	Find alternatives for supplemental feeding			

Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)	1		
	Landscape design	1		
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations	1		
	Farm activity and production diversification			

Main observations

- No risk management tools intervention, so no insurance system supported by the CAP
- An intervention specifically targets agroforestry systems
- An intervention targets the use of more adapted and resistant species: P1-31.1 — Use of resistant and adapted species and varieties
- The Ecoscheme intervention are well identified to meet the SO4 but ENVCLIM interventions are focused on the conservation of genetic diversity.
- Sectoral interventions to meet the SO4 for fruit and vegetables

CAP Strategic Plan (CSP) of Ireland (IE)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
Obj4.N4 - Encourage climate adaptation	3	1 (different practices supported)	4	2		2		2	

Other needs, out of the SO4, related to **climate change adaptation:**

- Obj1.N4 Encourage farm diversification to improve the resilience of the agri-food sector
- Obj1.N5 Increase awareness of risk management tools and encourage financial planning to improve resilience
- Obj5.N3 Improve soil health

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- Climate Action Plan 2021
- Ireland's National Energy and Climate Plan (NECP) 2021-2030

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures	1	1	
	Improve soil structure to increase water retention capacity and improve drainage	1	3	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	1	1	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity		1	
	Better manage crop water demand			
	Improve crop diversification and rotation	1	2	
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals	1	1	
	Improve pasture and grazing management to match stocking densities to forage production	1	1	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design	1	1	
	Develop and implement agricultural adaptation plans / contingency plan			

Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations	1		
	Farm activity and production diversification			

Main observations

- 1 eco-scheme intervention which brings together different practices, but it is an “eco-scheme for all farmers". It can lead to maintaining the status quo.
- No SO4 interventions for the specific sectors
- 2 MAEC interventions (general and cooperation) which are complementary to the eco-scheme and also bring together different practices.
- Other envclim interventions: genetic resources, sheep improvement scheme, straw integration measure, suckler carbon efficiency program, organic, dairy beef welfare scheme, etc.
- No insurance system supported by the CAP
- Other needs that are not linked to the SO4 in the CSP but which could support climate change adaptation practices

CAP Strategic Plan (CSP) of Latvia (LV)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
SM4 V7 - Support climate change adaptation implementation of measures	1	3	6	2		3			

Other needs, out of the SO4, related to **climate change adaptation:**

- SM5 V1 - Improving the quality of the soil by promoting the improvement of the structure, sustainable management
- SM5 V4 - To promote the improvement of knowledge and experience exchange for sustainable practices
- SM5 V7 - Ensure the availability and efficient use of water resources, mitigating the climate risks caused by change

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- Climate change adaptation plan for the period up to 2030

Adaptation solutions promoted

		CSP measures that promote/support the implementation of identified adaptation practices		
Risks related to extreme weather events (and main climatic causes)	**Adaptation solutions**	PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures			
	Improve soil structure to increase water retention capacity and improve drainage	3		
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers		1	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity	1		
	Better manage crop water demand			
	Improve crop diversification and rotation	1		
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production	1		
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design		1	
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			

	Buy insurance against weather and climate			1
	Other risk management tools			
	Use of precision farming: tillage and timing of operations	1		
	Farm activity and production diversification			

Main observations

- No intervention identified in the CSP to meet the SM4 V10
- No intervention related to the reduction of grazing pressure
- The eco schemes which supports the adaptation practices are well identified to meet the SO4 (except TM4.4 – Favourable farming practices)
- Intervention for buffer but not for hedges
- Insurance system supported by the CAP

CAP Strategic Plan (CSP) of Lithuania (LT)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
D.2- Apply technologies that reduce GHG emissions and increase soil organic carbon	2	14	1	2	1	1			
D.4 - Increase farm resilience to climate change risks through modern water management systems	3		1						

Other needs, out of the SO4, related to **climate change adaptation:**

- a.1 - Maintain the continuity and sustainability of agricultural activities
- a.6 - Promote the use of risk management measures on farms
- b.3 - Upgrade existing drainage systems
- e.1 -Apply agricultural practices to prevent soil erosion, especially on cultivated slopes

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change): /

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures	1		
	Improve soil structure to increase water retention capacity and improve drainage	5	1	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	2		
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity	1		
	Better manage crop water demand			
	Improve crop diversification and rotation	5		
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production	1		
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design	2		

Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			1
	Other risk management tools			1
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- Insurance system and mutual funds systems supported by the CAP
- Few Envclim interventions, therefore few to respond to adaptation issues
- Many Ecoschemes interventions support adaptation practices
- Sectoral interventions to meet the SO4 for fruit and vegetables

CAP Strategic Plan (CSP) of Luxembourg (LU)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
B4.3 - Promote the efficient use of water resources	1								
B4.5 - Provide resilience in the face of climate change	2			1					
B4.6 - Improve forage autonomy	3	2							

Other needs, out of the SO4, related to **climate change adaptation:**

- B2.4 - Promote the diversification of the agricultural production
- B1.5 - Strengthen the resilience of the agricultural sector to climate change and other risks
- B5.4 - Ensuring soil fertility and combating soil degradation

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- Stratégie et le plan d'action pour l'adaptation aux effets du changement climatique au Luxembourg 2018-2023
- Stratégie nationale à long terme en matière d'action climat « Vers la neutralité climatique en 2050

Adaptation solutions promoted

		CSP measures that promote/support the implementation of identified adaptation practices		
Risks related to extreme weather events (and main climatic causes)	**Adaptation solutions**	PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures		1	
	Improve soil structure to increase water retention capacity and improve drainage	3	4	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	1		
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity		1	
	Better manage crop water demand			
	Improve crop diversification and rotation	1	3	
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production		2	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			

	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design	1		
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- No intervention in the CSP linked to the first need identified
- Few interventions identified to meet the SO4: no INVEST, RISK, COOP, KNOW or Ecoscheme interventions
- No risk management tools supported by the CAP
- One ENVCLIM intervention in favor of reduction grazing pressure

CAP Strategic Plan (CSP) of Poland (PL)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II –INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
CS 4. P2 - Adaptation of agriculture and forestry to climate change — reducing weather and disease risks	1	2	1	4		1		1	
CS 4. P6 - Raising knowledge on climate change mitigation and adaptation	Beyond Priority							1	4

Other needs, out of the SO4, related to **climate change adaptation:**

- CS 1. P6.- Mitigating the effects of price and production risk — weather, natural disasters, pests, diseases
- CS 1. P9'S.- Increasing the use of risk management instruments
- CS 5. P3'S -Improving water quality

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- Priority Action Framework for the Natura 2000 Network (PAF).
- Water management plans
- National Energy and Climate Plan 2021-2030
- Second National Action Plan for Poland to mitigate the risks associated with the use of plant protection products for the period 2018-2022

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods (Main climatic causes of risk : Increase of extreme events frequency ; Loss of soil water retention capacity)	Enhance flood plain management			
	Ecosystem compatible drainage	1		
	Reduce grazing pressures	1	1	
	Improve soil structure to increase water retention capacity and improve drainage	2	2	
	Increase rainfall interception capacity	1		
	Introduce contoured hedgerows and buffers		1	
Increased risks of drought and water scarcity (Main climatic causes of risk : Decreased annual and/ or seasonal precipitation ; Increase in the frequency of extreme conditions (droughts and heat waves))	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity	1	1	
	Better manage crop water demand			
	Improve crop diversification and rotation	1	2	
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production			
	Find alternatives for supplemental feeding			
	Active protection against frost			

Increased risks of frost, hail and storms	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)		1	
	Landscape design		1	
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			1
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- The 2 eco scheme interventions identified to meet the SO4, allow the implementation of practices to adapt agriculture to climate change
- One eco scheme intervention (identified to meet the SO4) aims to increase rainfall interception And 4.5 — eco-chemistry — Retention of water on permanent grassland)
- One eco scheme includes a practice whose title explains the desire to reduce the grazing pressure
- One intervention to adapt to extreme climate event specific to fruit and vegetables sector
- Envclim intervention support the sustainable and organic agriculture, extensive breeding and there is one specific intervention for agroforestry and trees.
- No insurance system supported by the CAP but support to mutual funds

CAP Strategic Plan (CSP) of Portugal (PT)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
PTOE4N1- Increasing resilience to climate change impacts — extreme climate events	1		1	9		12			2

Other needs, out of the SO4, related to **climate change adaptation: /**

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- National Energy and Climate Plan 2020-30 (PNEC2030)
- National Climate Change Adaptation Strategy
- Climate Change Adaptation Action Programme P3-AC

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage	1		
	Reduce grazing pressures		2	
	Improve soil structure to increase water retention capacity and improve drainage	4	5	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers		1	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency	1	1	
	Improve soil moisture retention capacity	2	2	
	Better manage crop water demand		1	
	Improve crop diversification and rotation	2	2	
	Introduction of more heat tolerant species/breeds		1	
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production	1	5	
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)	2	4	
	Landscape design		1	
	Develop and implement agricultural adaptation plans / contingency plan			

Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			3
	Other risk management tools			
	Use of precision farming: tillage and timing of operations			
	Farm activity and production diversification			

Main observations

- An insurance system is supported by the CAP. There are 3 insurance interventions which correspond to 3 areas of the country (mainland, Azores, Madeira)
- Sectoral interventions to meet the SO4 (fruit and vegetables)
- A lot of interventions increasing the soil structure (Eco scheme and Envclim), including direct seeding and soil conservation measures
- Various measures of Envclim support pasture management including conservation of agroforestry mosaic
- Agroforestry: conservation of existing agroforestry systems

CAP Strategic Plan (CSP) of Slovenia (SI)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II –COOP	PILLAR II - KNOW
P14- Maintaining and ensuring the quality of agricultural soils and preventing erosion	1	6	1	3		2		1	
P15-Adaptation to climate change in agriculture and forestry	1	8	2	3		3		1	1

Other needs, out of the SO4, related to **climate change adaptation:**

- P03- Risk management to achieve sustainable farm income and resilience
- P17- Reducing the negative impacts of agriculture on soil, surface and groundwater conditions

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- National Energy Climate Plan (NECP)

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures	1		
	Improve soil structure to increase water retention capacity and improve drainage	2	2	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers		1	
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity	1		
	Better manage crop water demand			
	Improve crop diversification and rotation	2	2	
	Introduction of more heat tolerant species/breeds		2	
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production		1	
	Find alternatives for supplemental feeding		1	
Increased risks of frost, hail and storms	Active protection against frost		1	
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			

	Landscape design		1	
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations		1	
	Farm activity and production diversification			

Main observations

- There is one intervention that identified higher endurance of local breeds and varieties in the event of natural disasters (e.g., heat stress, drought).
- No risk management intervention (insurance, mutual funds) supported by the CAP
- Various practices are supported by interventions that meet the needs of SO4
- There is only one landscape intervention which is not in SO4

CAP Strategic Plan (CSP) of Spain (SP)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
04.03 - Reduce the vulnerability of agricultural, livestock or forestry systems to the impacts of climate change and extreme events by encouraging their adaptation	1	5	2	4	1	2			
04.04 - Promoting the diversification of production and the inclusion of crops and breeds with greater potential for adaptation to climate change due to their lower vulnerability in future climate change scenarios	2								
04.07 - R & D & I on climate change mitigation and adaptation	3		2	3		3			
04.09 - Knowledge transfer in mitigation and adaptation	2								
04.10 - Minimising the risks due to extreme weather events, in addition to enhancing agricultural insurance systems in relation to the adversities of the sector due to the effects of climate change	3			1		1			

Other needs, out of the SO4, related to **climate change adaptation:**

- 01.05 Role of aid in risk reduction
- 01.06 Adaptation of the Spanish agricultural insurance system (no intervention linked to this need int the CSP)
- 02.06 Promote own resources for animal feed
- 05.04 Reducing erosion and desertification
- 05.05 Soil quality

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- - National Agricultural Insurance Scheme
- - National Climate Change Adaptation Plan 2021-2030
- - Integrated National Energy and Climate Plan 2021-2030

Adaptation solution promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures	2		

	Improve soil structure to increase water retention capacity and improve drainage	6	4	
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers	1		
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency		1	
	Improve soil moisture retention capacity	3	2	
	Better manage crop water demand			
	Improve crop diversification and rotation	6		
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production	2		
	Find alternatives for supplemental feeding			
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses		1	
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)		1	
	Landscape design	1		
Increased risks of extreme weather events as a whole (droughts, floods, hail, frost, etc.)	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			
	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations		1	
	Farm activity and production diversification			

Main observations

- Needs linked to SO4 are very detailed
- No Know, Coop or Risk interventions that meet the SO4
- No insurance system supported by the CAP in the CSP
- Spain is the only member state that offers aid for greenhouse production in ENVCLIM
- There is many eco schemes which support adaptation practices because there is one intervention per type of plot (slope or type of soil)

CAP Strategic Plan (CSP) of Sweden (SE)

First insights regarding instruments and solutions promoted to support the sector to pro-actively mitigate effects of extreme weather events caused by climate change

Main strategy towards climate change adaptation (SO4)

Identification of needs related to adaptation (SO4)	PRIORITY	Number of measures per pillar and intervention areas linked to SO4							
		PILLAR I - Direct Payments (including eco-scheme)	PILLAR I - Sectoral Interventions	PILLAR II – ENVCLIM	Payments for specific disadvantages	PILLAR II – INVEST	PILLAR II – RISK	PILLAR II – COOP	PILLAR II - KNOW
SO4BEHOV3 Adapt production to climate change and reduce relative impact on the climate	2	1	2			1		2	1

Other needs, out of the SO4, related to **climate change adaptation:**

- SO5BEHOV1 - Reducing pressure on soil, air and water
- SO6BEHOV2 - Preserve valuable grasslands

Additional instruments outside the CAP to achieve SO4 (regarding adaptation to climate change):

- Sweden's integrated national energy and climate plan
- The national environmental objectives

Adaptation solutions promoted

Risks related to extreme weather events (and main climatic causes)	Adaptation solutions	CSP measures that promote/support the implementation of identified adaptation practices		
		PILLAR I - ECOSCHEME	PILLAR II – ENVCLIM	PILLAR II – RISK MANAGEMENT TOOL
Increased risks of floods	Enhance flood plain management			
	Ecosystem compatible drainage			
	Reduce grazing pressures			
	Improve soil structure to increase water retention capacity and improve drainage	2		
	Increase rainfall interception capacity			
	Introduce contoured hedgerows and buffers			
Increased risks of drought and water scarcity	Improve water use / irrigation efficiency			
	Improve soil moisture retention capacity	1		
	Better manage crop water demand			
	Improve crop diversification and rotation	2		
	Introduction of more heat tolerant species/breeds			
	Increase shelter for animals			
	Improve pasture and grazing management to match stocking densities to forage production		3	
	Find alternatives for supplemental feeding		1	
Increased risks of frost, hail and storms	Active protection against frost			
	Shade and nylon hail protection nets for orchards			
	Use of greenhouses			
	Develop agroforestry (Introductions of silvo-arable or silvo-pastoral systems)			
	Landscape design			
Increased risks of extreme weather events	Develop and implement agricultural adaptation plans / contingency plan			
	Increase the access to early warning systems and climate services dedicated to agriculture			

as a whole (droughts, floods, hail, frost, etc.)	Integrating adaptation into farm advice			
	Buy insurance against weather and climate			
	Other risk management tools			
	Use of precision farming: tillage and timing of operations	1		
	Farm activity and production diversification			

Main observations

- No ENVCLIM intervention to meet the need "Adapt production to climate change and reduce relative impact on the climate". The analyse by key words underlines only 3 ENVCLIM interventions which support adaptation practices. These interventions support only adaptation practices linked to breeding
- One intervention specific to precision farming in the ecoscheme
- No risk management tools supported by the CAP
- No landscape intervention for hedge or buffer
- One intervention for supplemental feeding for sheeps

The study aims, first, to provide the European Parliament with an overview of the challenges faced by the agricultural sector regarding the evolution of climate extreme events in the European Union. Then, the study highlights existing solutions to help farmers mitigate the effects of extreme weather events and recover from climate-related disasters. Finally, it analyses existing policy instruments supporting these solutions, including those promoted by Member States under the new CAP programming (2022-2027).

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