

Study on climate change adaptation in agriculture in the EU, with a focus on water management

Final report



Written by AND International, ADE, AFC and ICF
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Directorate-General for Agriculture and Rural Development
Directorate AGRI A — Strategy and Policy Analysis
Contact dissemination: Unit A3 — Policy Performance
E-mail: AGRI-EVALUATION@ec.europa.eu

Directorate B - Sustainability
Contact content: Unit B2 Environmental Sustainability
E-mail: AGRI-B2@ec.europa.eu

*European Commission
B-1049 Brussels*

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Authors:

AND International: Tanguy CHEVER, , Anukriti GOEL, Clement LEPEULE, Severine RENAULT,
ADE: Monika BECK, Sarah BODART,
AFC: Nicolas HEINRICH, Lena KAMPA
ICF: John ELLIOTT, Katarzyna JASKIEWICZ, Jenny CASTILLO, Noah TOZER, Jakob RUSTIGE.

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Glossary

Term	Description
Agri-Environment-Climate Commitments (AECC)	Agri-environment-climate commitments are voluntary management obligations undertaken by farmers and other beneficiaries under a CAP Strategic Plan to deliver environmental, climate and biodiversity benefits that go beyond conditionality. Payments compensate for the additional costs incurred and income foregone, with commitments lasting at least five years unless a longer period is justified by the nature of the action.
Climate Change	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.
Climate Change Adaptation (CCA)	The process of adjustment to actual or expected climate and its effects to moderate harm or exploit beneficial opportunities.
Climate Change Mitigation (CCM)	Human interventions to reduce emissions or enhance the sinks of greenhouse gases.
Cohesion Policy	The Cohesion Policy is the EU's main investment policy, established under Articles 174-178 TFEU, aimed at strengthening social, economic and territorial cohesion by reducing disparities between regions. Implemented through the European Regional Development Fund (ERDF), the Cohesion Fund (CF) and the European Social Fund Plus (ESF+), it supports multiannual programmes under shared management and co-financing, supporting SMEs, regional development, infrastructure, innovation, low-carbon transition, social inclusion and employment.
Conditionality	A set of environmental and climate-related requirements that farmers must meet to receive full payments under the CAP. It includes statutory management requirements (SMRs), which apply to all farmers whether or not they receive support under the CAP and standards for good agricultural and environmental conditions of land (GAEC), which apply only to farmers receiving support under the CAP.
Eco-scheme	Eco-schemes are voluntary interventions under the CAP Strategic Plans, established under Article 31 of Regulation (EU) 2021/2115, forming the second pillar of the CAP's green architecture alongside conditionality and agri-environment-climate commitments. They provide payments to farmers and other beneficiaries for practices that go beyond mandatory conditionality to deliver measurable environmental and climate benefits, including the protection and enhancement of biodiversity, soil, water and carbon sequestration.
Effective adaptation	Adaptation that moderates harm or exploits beneficial opportunities, to reduce climate risk by either reducing vulnerability or exposure to CC related impact.
European Agricultural Fund for Rural Development (EAFRD)	The EAFRD finances the EU's contribution to rural development programmes (RDPs), which consist of measures and projects that contribute to the EU-wide objectives of improving the competitiveness of agriculture, encouraging sustainable management of natural resources and climate action and achieving a balanced territorial development of rural economies and communities.
European Regional Development Fund (ERDF)	An EU fund that strengthens economic and social cohesion in the EU by financing investments that reduce imbalances between its regions.

Term	Description
Good Agricultural and Environmental Conditions (GAEC)	Good Agricultural and Environmental Conditions (GAECs) are mandatory under the CAP conditionality framework that all farmers and land managers must respect to receive area-based CAP payments. They define the baseline for sustainable agriculture by protecting soil, water, biodiversity and landscape features, and by maintaining carbon-rich areas. The GAEC framework includes: the maintenance of permanent grassland (GAEC 1); protection of wetlands and peatlands (GAEC 2); restrictions on burning arable stubble (GAEC 3); establishment of buffer strips along water courses (GAEC 4); soil protection measures to prevent erosion (GAEC 5); maintenance of minimum soil cover (GEC 6); crop rotation on arable land (GAEC 7); retention of landscape features and non-productive areas (GAEC 8); and protection of environmentally sensitive permanent grasslands (GAEC 9).
Green architecture	EU green architecture refers to the environmental and climate framework of the CAP, comprising mandatory conditionality (including statutory management requirements and GAEC standards), voluntary eco-schemes (Article 31) and agri-environment-climate commitments (Article 70). It ensures that CAP interventions contribute to biodiversity, soil and water protection, landscape preservation, carbon sequestration and climate mitigation and adaptation.
Green interventions	Interventions in support of the environment, climate and animal welfare, including eco-schemes, AECC, etc.
Maldaptation	Adaptation with negative consequences that increase climate vulnerability, that shift vulnerability or exposure, or that erode sustainable development now or in the future.
Recovery and Resilience Facility (RRF)	Temporary instrument under NextGenerationEU to implement ambitious reforms and investments by MS.
River Basin	As defined in Article 2(13) of Directive 2000/60/EC, a river basin refers to the area of land from which all surface run-off flows through a sequence of streams rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta.
River Basin Management Plans (RBMPs)	River Basin Management Plans (RBMPs) are the principal instruments through which MS implement the Water Framework Directive at the river-basin level. They provide a comprehensive assessment of water body status, characterise pressures and impacts, identify protected areas and define Programmes of Measures to achieve good ecological, chemical and quantitative status of surface and groundwater. RBMPs integrate flood and drought risk management, climate adaptation, stakeholder participation and coordination across sectors and EU policies, and are updated every six years in line with the Directive's planning cycle.
Scientific Committee	The Scientific Committee, composed of academics from renown research institutes and universities in different MS with various areas of expertise, provided specific assistance regarding methodologies, peer review and analytical support to the core study team.
Water Framework Directive	Water Framework Directive (WFD, Directive 2000/600/EC) establishes the EU framework for integrated water management to achieve good status of all water and prevent deterioration. It requires river basin district planning, water body characterisation, monitoring, and Programmes of Measures, implemented in six-year cycles. The current programming period corresponds to the third cycle of RBMPs (RBMP3) for 2022-2027.
Water resilience	The role of water in safeguarding and sustaining a particular desired state of a social-ecological system, ranging from sustaining the state of ecosystems and biomes, to the stability of regional weather and climate systems, and the ability of the hydrological cycle to maintain stable water supply for societies and ultimately the state of the biosphere and the Earth system (through moisture feedback, climate forcing, and regulating biomass growth in terrestrial ecosystems).

List of acronyms

AKIS	Agricultural Knowledge and Innovation Systems
CAP	Common Agricultural Policy
CC	Climate Change
CCA	Climate change adaptation
CCIV	Climate Change Impact, Vulnerability and risk
CINEA	European Climate, Infrastructure and Environment Executive Agency
CREA	Council for Agricultural Research and Economics
CS	Case Studies
CSP	CAP Strategic Plan
DG AGRI	Directorate-General for Agriculture and Rural Development
DG CLIMA	Directorate-General for Climate Action
DG ENV	Directorate-General for Environment
DG REGIO	Directorate-General for Regional and Urban Policy
EAFRD	European Agricultural Fund for Rural Development
EEA	European Environment Agency
EIP AGRI	Agricultural European Innovation Partnership
EU	European Union
EUCRA	European Climate Risk Assessment
FADN	Farm Accountancy Data Network
GHG	Greenhouse gas emissions
IMIDA	Instituto Murciano de Investigación y Desarrollo Agrario y Medioambiental
IPCC	Intergovernmental Panel on Climate Change
ISSG	Inter-service steering group
JRC	Joint Research Centre
LULUCF	Land use, land use change, and forestry
MS	Member states
NGO	Non-Governmental Organisation
PMEF	Performance Monitoring and Evaluation Framework
RFS	Request for Service

SMR	Statutory Management Requirements
SO	Specific Objectives
SQ	Study Question
TOR	Terms of reference
WFD	Water Framework Directive
WP	Work package

Country and Region Abbreviations

AT	Austria
BE	Belgium
BE-FL	Flanders (Belgium)
BE-WL	Wallonia (Belgium)
BG	Bulgaria
CY	Cyprus
CZ	Czechia
DK	Denmark
DE	Germany
EE	Estonia
ES	Spain
FI	Finland
FR	France
EL	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxemburg
LV	Latvia
MT	Malta
NL	Netherlands
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia

Abstract

European agriculture is increasingly affected by climate change, with rising temperatures, more frequent droughts, water scarcity and extreme rainfall events placing significant pressure on production systems, natural resources and rural economies. The financial impact of climate change on EU farms is estimated at EUR 28.3 billion per year at EU level and forecast to rise. In this context, strengthening climate change adaptation and water resilience has become a central priority for the European Union. This study provides comprehensive evidence on available adaptation practices, tools and strategies, their suitability and maladaptation risks, behavioural and economic drivers for implementation, and the role of Common Agricultural Policy (CAP) and other policy instruments in supporting climate resilient agricultural systems.

The study applies an integrated methodology combining a systematic literature review, EU-wide farmer and stakeholder surveys, over 40 interviews, 2 focus groups, 2 workshops, and five in-depth regional case studies. This multi-layered approach with triangulation across farm, regional, national and EU levels, enabled development of a structured inventory of more than 300 adaptation practices and insight into both practical and systemic dimensions of climate adaptation in EU agriculture.

Findings suggest that the CAP and other policy mechanisms support a broad range of adaptation-relevant actions. The coherence between the CAP and the Water Framework Directive was reinforced in the 2023-2027 period but with varying implementation by the respective national authorities. There is an emphasis on addressing current climate impacts through reactive and incremental adaptation rather than building resilience to future climate risks. Key gaps include: a lack of shared concept of climate change adaptation, a lack of comprehensive stakeholder engagement in designing long-term adaptation strategies, insufficient diagnostic tools for farmers to identify their adaptation needs and uneven implementation of the Water Framework Directive across Member States.

The study concludes that enhancing water resilience will require stronger water demand management, improved soil health, integrated river basin-level governance, and a more focused and coordinated effort by the public and private sector to enable sustained, transformative adaptation across EU agriculture, while avoiding maladaptation.

L'agriculture européenne est de plus en plus affectée par le changement climatique, avec la hausse des températures, la fréquence accrue des sécheresses, la rareté de l'eau et des épisodes de précipitations extrêmes qui exercent une pression significative sur les systèmes de production, les ressources naturelles et les économies rurales. L'impact financier du changement climatique sur les exploitations agricoles de l'UE est estimé à 28,3 milliards d'euros par an à l'échelle européenne et devrait augmenter dans les années à venir. Dans ce contexte, le renforcement de l'adaptation au changement climatique et de la résilience hydrique est devenu une priorité centrale pour l'Union européenne. Cette étude fournit des éléments probants et complets sur les pratiques d'adaptation disponibles, leur pertinence et les risques de maladaptation, les moteurs comportementaux et économiques de leur mise en œuvre, ainsi que sur le rôle des politiques européennes et nationales, en particulier la politique agricole commune (PAC), dans le soutien à des systèmes agricoles résilients au climat.

L'étude s'appuie sur une méthodologie intégrée combinant une revue systématique de la littérature, des enquêtes menées auprès d'agriculteurs et de parties prenantes à l'échelle de l'UE, plus de 40 entretiens, des groupes de discussion et cinq études de cas régionales approfondies. Cette approche multi-niveaux, fondée sur la triangulation entre les échelons de l'exploitation, de la région, du pays et de l'UE, a permis de constituer un inventaire structuré de plus de 300 pratiques d'adaptation et d'apporter un éclairage tant sur les dimensions pratiques que systémiques de l'adaptation au climat dans l'agriculture européenne.

Les résultats montrent que la PAC et d'autres instruments politiques soutiennent un large panel d'actions pour l'adaptation de l'agriculture au changement climatique. La cohérence entre la PAC et la Directive-cadre sur l'eau s'est renforcée sur la période 2023-2027. Cependant, son application varie selon les autorités respectives dans les Etats membres. L'accent est davantage mis sur la réponse aux impacts climatiques actuels par des mesures réactives et incrémentales que sur le renforcement de la résilience face aux risques climatiques futurs. Les principales lacunes identifiées sont : l'absence d'une compréhension partagée du concept d'adaptation, une participation limitée des acteurs dans l'élaboration de stratégies long-terme d'adaptation, un manque d'outils de diagnostic pour aider les agriculteurs à identifier leurs besoins d'adaptation et une application hétérogène de la Directive-cadre sur l'eau dans les Etats membres.

L'étude conclut que renforcer la résilience hydrique nécessitera une gestion accrue de la demande en eau, une amélioration de la fonctionnalité des sols, une gouvernance intégrée à l'échelle des bassins versants, ainsi qu'un effort public et privé plus ciblé et coordonné pour favoriser une adaptation durable et transformative de l'agriculture européenne, tout en évitant la maladaptation.

Introduction

This document constitutes the Final Report prepared for the Directorate General Agriculture and Rural Development of the European Commission (DG AGRI) in response to the Request for Service (RFS) 'Study on CCA in the EU, focus on water management' which is part of the 'framework contract for analytical services on environmental and climate aspects of agriculture, animal welfare, animal and plant health, and forestry'. It is submitted by a consortium led by AND International in partnership with ADE, AFC, and ICF.

The assignment examined CCA across the EU-27 and across agricultural sectors, covering the full range CC impacts but with a particular focus on water-related climate impacts. The study duration was 13 months from the project start date of 13 November 2024. This study aimed to understand the baseline position for CCA in EU agriculture, focusing on the current knowledge on adaptation practices, strategies and tools, and what is being done regarding the development and implementation of adaptation by private and public stakeholders at local, regional and national level (SQ1), what makes adaptation practices and strategies suitable or not (SQ2), what factors affect farmers decisions to adapt their farming practice in response to CC (SQ3), what the costs and benefits of 'good' adaptation practices and strategies are (SQ4), and how to increase agricultural resilience to water-related CC impacts (SQ5).

It also considered how the CAP and other policy instruments are currently supporting farmers adaptations to CC and water resilience (SQ6). Finally, the study considered how the scale and pace of adaptation can be strengthened going forward, in particular, how the CAP and other policy mechanisms can help farmers and others to adapt through addressing gaps and barriers and improving the case for action at farm level, and how adaptation across farms is influenced by and contributes to territorial and sector adaptation needs, and the scope for integrated adaptation (SQ7).

Study overview and report structure

This report is structured as follows:

- Section 1 method for research activities undertaken under this assignment;
- Section 2 presents mapping of the evidence in relation to the study questions (SQs);
- Section 3 presents the study conclusion, and
- Section 4 presents the lessons learned.

1 Methodological approach

The study methodology was designed to address seven SQs, and consisted of three key elements:

- Collection of primary evidence through research activities such as focus groups, online workshops, online surveys, interviews, and case studies.
- Analysis of primary and secondary evidence to produce a detailed response to the SQs.
- Iterative development of conclusions and lessons learned based on the analysis and synthesis of evidence, and feedback from the Inter-service steering group (ISSG).

The methods used to collect primary and secondary evidence for this assignment, as well as their relevance to each specific question, are presented in Table 1.

Table 1. Methods for primary and secondary evidence by SQ

Evidence type	Research activity	SQ1	SQ2	SQ3	SQ4	SQ5	SQ6	SQ7
Secondary evidence	Literature review			X		X	X	X
	Systematic review and inventory development	X	X		X			
Primary evidence	Online surveys	X	X	X	X	X	X	
	Interviews	X	X	X	X	X	X	X
	Focus groups/workshops	X	X	X	X	X	X	X
	Case studies	X	X	X	X	X	X	

1.1 Limitations

While this study contributes valuable insights to the existing body of evidence on CCA in the EU, several limitations must be acknowledged. From a methodological perspective, the collection of direct data from farmers presents inherent challenges. Surveying farmers online presents many well-known challenges, as discussed in the relevant literature (Avemegah et al. 2021; Pennings et al. 2002). Low response rates and the voluntary nature of participation introduce the possibility of partial or biased datasets, which is a key limitation as the data collected may not accurately reflect the broader population. In this context, the results reflect the views of farmers who were willing to participate, which may not necessarily align with the general population. Additionally, the reliance on self-reported data and the voluntary nature of adaptation practices also increases the possibility of bias. These limitations could be addressed in future work by either conducting phone-based interviews with a stratified sample and an incentive to participate or incorporating questions on adaptation in the annual questionnaires addressed to farmers' panels under the Farm Accountancy Data Network (FADN).

Additionally, there is an overarching lack of comprehensive data on implementation of CCA in agriculture, compounded by difficulties in consistently defining farming practices across contexts. For instance, the concept of adaptation is not universally understood among farmers, leading to potential inconsistencies and ambiguities in responses and further complicating the analysis. This limitation hampers the ability to determine the true extent of uptake for many practices, especially those beyond soil management, thus limiting the scope and depth of analysis.

Despite the utility of the Agri-Food Data Portal and the CAP data for informing research on agricultural practices and adaptation, several significant limitations must be recognised. Firstly, although the portal provides information on implementation, the level of detail is not sufficient to carry out an assessment of how and at what level (e.g., implementation per hectare) climate adaptation measures have been implemented. Therefore, the study team can only determine how certain interventions might support specific practices but cannot fully assess the overall extent of implementation.

1.2 Definitions

During the scoping phase, the study team developed a set of definitions to delineate the parameters for exploring strategies, tools, and changes in farming practices. These definitions were intended to provide guidance on what was considered within or outside the scope of the study and are presented in Figure 1.

Figure 1. Definitions: Strategies, tools and changes in farming practices

Strategies are long-term plans meant to enhance agriculture's resilience and adapt to climate change. Relevant strategies may also articulate agriculture's needs with those of industry, citizens, and nature. Some examples include:

- Strategies to re-think and transform the manner water is collected, transported, used across a catchment area, addressing and adjudicating competing demands
- Strategies to re-design flood risk management, combining grey and nature-based solutions, across a catchment area
- Strategies to accompany the transition of a group of farmers from conventional to regenerative agriculture

Tools are designed to help stakeholders make and implement climate adaptation decisions. For example:

- Tools to anticipate climate impacts (e.g., climate forecasting models, extreme weather warning apps)
- Tools to choose alternative varieties / breeds depending on agro-climatic conditions and forecasted climate changes and anticipate their effectiveness in different agro-climatic conditions
- Tools/equipment to better manage limited resources, including water (e.g., precision farming sensors, irrigation controllers)
- Tools to mitigate climate impacts on revenue (e.g. crop insurance, risk sharing)

Changes in farming practices refer to operational modifications that have been implemented at farm-level (and are therefore observable) to adapt to climate change

Strategies, tools and changes in farming practices cannot be policy instruments

1.3 Methods for secondary evidence

1.3.1 Literature review

The literature review aimed to address SQ1, SQ2, SQ3, SQ5, SQ6 and SQ7, and was a key element to; inform the research design of the study; contribute to the evidence base and identify knowledge gaps to answer the SQs. Search strings were developed based on core themes and iteratively refined to improve relevance, with geographic and temporal filters applied to limit results to Europe and the last 10 years. Studies were screened using defined inclusion and exclusion criteria, focusing on empirical, regionally relevant work. The review was conducted using a standardised search strategy across multiple academic databases (Web of Science, Scopus, and AgEcon Search), complemented by grey literature sources. Throughout the study, the search strategies were revised to broaden the scope and improve thematic relevance. More than 100 references were consulted based on the study team's own research and exchange with the ISSG.

1.3.2 Systematic review and inventory development

The study team conducted a systematic review of secondary data with the aim of developing a comprehensive inventory of farming practices related to CCA in the EU context. The inventory of practices was developed as an Excel database and contains defined categories per practice. The systematic review contributed to answering questions SQ1, SQ2, and SQ4. This task involved a systematic review of available documents following the steps below;

- Reviewing the evidence available;
- Establishing an inventory of relevant farming practices based on the JRC classification scheme (European Commission- JRC 2024)¹;
- Developing a synthesis of findings of existing documents and data on interventions (for example from Agri-food Data portal) per SQ/farming practice; and
- Assessing knowledge gaps.

A total of 281 changes in farming practice, 30 tools and 30 strategies were identified and consolidated into the inventory. The changes in practice were mostly extracted from:

- AWA AgriAdapt database (referenced 135 times in the inventory),
- CAMBIA library (referenced 76 times),

¹ The JRC developed a classification scheme of farming practices to facilitate the systematic reporting, and evaluation and monitoring processes of interventions defined in the MS CAP Strategic Plans. This classification also aimed to enable the extraction and aggregation of similar interventions across different MS and different CAP areas.

- ClimateFarmDemo project (referenced 15 times),
- iMAP (referenced 10 times), and
- Other references including academic sources (51 references).

Table 2 presents an overview of the main categories included in the inventory, and the number of corresponding adaptation practices identified, noting that each measure may correspond to several sub-categories. The inventory was then validated by ten experts on climate adaptation in agriculture (including two experts from the study's Scientific Committee). These experts contributed further insights in areas where data was not available or sufficient. Each expert was assigned thirty practices matching their expertise. In addition to validating the team's assessment. The experts also provided their own judgement on:

- The level of uptake of each practice and the geographic aptness of the practices in the different agro-climatic zones, and
- Relevant tools and strategies they were aware of to complement other data collection activities.

In the final phase of the study, the team conducted a thorough data cleaning process to enhance the inventory's functionality.

Table 2. Overview of main categories and number of adaptation practices

Intervention dimension	Subcategory (indicative no. of corresponding entries)
Main categories	General (20), Landscape (18), Soil management (43), Crop protection (37), Crop resilience (43), Livestock protection (37), Livestock resilience (32), Product processing (6), Water management (45) (sub-categories: supply (7) – use (27)– storage (5)- drainage(4))

Intervention dimension	Subcategory (indicative no. of corresponding entries)	
JRC label	A1X - improved livestock feeding strategies (27) A2X - Animal trait selection programmes (3) A3X - Biosecurity and hygiene measures and other measures to reduce anti-microbials use (2) A5X - Improved housing conditions (12) A7X - Beekeeping (2) A6 - Other animal welfare practices (6) A8 - Livestock density limits at farm level (1) B2X - Renewable energy production (1) E1X - Precision agriculture (4) F2X - Fertilization practices to reduce nutrient losses (3) F3X - Soil amendments (4) F4X - Use of specific fertilizer types or manure (10) G1X - Grazing management (5) G2X - Grassland management (6) L1X - Presence of landscape features (8)	L3X - Agroforestry (1) L5X - Management of wetland/peatland (2) L6X - Modification of the structure of fields (3) O1X - Organic farming (1) P1X - Non-chemical control (3) R1X - Crop rotation or Crop diversification (30) S1X - Tillage (10) S2X - Soil cover (13) S3X - Machinery use (7) S4 - Other practices to combat erosion (2) W1X - Water management (48) Z2X - Agrobiodiversity (2) No applicable JRC label (63)
CC event / impact (to which the measure responds)	Heatwaves (127), Droughts / reduced precipitation (146), Floods / heavy precipitation events (73), Intense / late frost (50), Wind / storm (35), Erosion (33), Salinisation (11), Rising temperatures (10), New / worse pests & diseases (7), Hail (5), Sea level rise / salt wedge intrusion (3), Wildfires (1)	
Production sector & subsector	Crops (190) Non-specific (62) Vineyards (53) Perennial crops (68) Horticulture (55) Arable (39) Perennial crops (16) Forage crops (9) Rice (1)	Livestock (67) Non-specific (36) Cattle (14) Pigs (1) Mono-gastric (1) Poultry (3) Ruminants (10) Crops & livestock (24)
Production system (if specified)	Rainfed (154) Non-specific (55) Controlled Environment Agriculture (CEA) (5)	Non-specific (51) Indoors (7) Extensive livestock systems (8)

1.4 Methods for primary evidence

1.4.1 Interviews

The main purpose of this activity was to gather data and contribute to the evidence base for answering the SQs. The interviews aimed to explore and address information gaps identified in the literature, improve understanding of key issues, and capture good practice examples. Moreover, the interviews served as an important tool to collect additional data on CC impacts beyond water issues and to gather supplementary information at European, national, and regional levels.

The interviews were conducted at three key stages:

- Scoping interviews
- Evidence gathering interviews
- Complementary targeted interviews to validate findings or improve understanding of specific elements identified throughout the study.

The scoping interviews were conducted with members of organisations with appropriate insight to provide direction on the study approach, particularly regarding the inventory development, and included, JRC, CREA, Bodensee Stiftung, CINEA-LIFE, ARPAE and EIP AGRI. The second stage involving interviews to gather evidence took place between July and September 2025 and overlapped with the third stage (complementary targeted interviews). During the second stage, the study team conducted interviews with various stakeholder groups as indicated in Table 3. This included interviews to collect data on the understanding of the concept of adaptation by EU level bodies involved in implementing and supporting CCA policies and instruments, state of play of water abstraction including in relation to WFD, and concrete applications of CCA such as through sectoral programmes and EIP AGRI operational groups.

The remaining evidence gathering interviews and additional complementary targeted interviews took place between September and October 2025. These sought to validate results and enhance specific elements identified throughout the study or raised by the ISSG. Potential interviewees were selected using multiple approaches, including snowballing from other research activities such as focus groups, or identification of relevant academics and research institutes cited in the literature reviewed. The selection of interviewees was based on their relevance to provide additional insight that had not been collected or explored through other research activities, or to address specific elements or gaps.

Table 3. Interviews conducted under this assignment

Stakeholder category	Description
Farmer groups / associations; Producer organisations / cooperatives (n=8)	The stakeholders consulted represent agricultural producer organisations and interprofessional bodies from Spain, France and Portugal, primarily in the olive and wine sectors. These include a representative of Spain's largest agri-food cooperatives, with an indicative membership of approximately 23 000 growers, and a representative from the Brussels delegation of a national federation representing approximately 27 000 members. In France, input was provided by the national interprofessional olive association, which coordinates producers and sectoral actors, alongside wine-sector bodies. A stakeholder from the cooperative of Beja was also consulted, which represents roughly 2 000 farmers.
Private sector (n=5)	Private stakeholders consulted span consultancies and financial institutions with critical roles in climate adaptation across Spain, Italy and France. In Spain, this included stakeholders specialised in financing for water user associations and farmers (covering over 900 associations nationwide). Stakeholders from advisory firms working at EU level, in Germany and Italy were also engaged. Their expertise focuses on water resilience, heat, and the implementation of regional adaptation plans. Moreover, French agri-food actors representing about 17 000 enterprises were consulted.
EU-level bodies (n=8)	The stakeholders consulted from EU-level bodies include agencies and service points involved in implementing and supporting EU policies and funding instruments (DG AGRI, EIB, CINEA, EIP-AGRI, point and coordinators of LEADER projects at EU-level, as well as technical partners engaged in adaptation initiatives such as Mip4Adapt).
Regional/province authorities (n=10)	The regional and national authorities consulted span France, Spain, Luxembourg and Germany, reflecting diverse governance levels and roles in agricultural and climate adaptation policy. This includes Chambers of commerce, Ministries of agriculture, and regional authorities. Expertise spanned from regional adaptation measures, the role of the CAP in CCA, irrigation modernisation and water efficiency measures, and viticulture.
Sectorial organisations (n=1)	The stakeholder consulted under the sectorial organisations category is a national-level body representing the wine sector in France. The organisation acts as an umbrella structure for a wide range of actors within the viticulture and wine-making value chain, including producers, cooperatives and related industry representatives.
River Basin authorities (n=3)	The stakeholders consulted under the river basin authorities' category include entities responsible for water resource management and planning at regional level. Two of the stakeholders represent river basin management authorities in France. The third stakeholder is an upper water authority in Germany, acting at regional level and with a mandate for water resource management.
Research institutions (n=6)	The research institutions consulted represent a mix of EU-level and national scientific bodies, including the EU's science and knowledge service (JRC), Italy's national agricultural research institute (CREA), a regional research centre in Murcia, Spain (IMIDA), Parma University (Italy), and Bodensee Stiftung (Germany).
NGOs (n=1)	The NGO consulted is based in Slovakia and led by a researcher specialised in water management and hydrology.

Stakeholder category	Description
Academic experts/ other experts (n=4)	The academic experts consulted include experts specialising in plant water stress, irrigation efficiency and water resources management.

The study team prepared a set of questions designed to address specific aspects of each SQ. This allowed interviewers to systematically collect new data (in relation to evidence gathering interviews) and explore hypothesis or gaps. Once the interviews were completed, the interview notes were mapped to the SQs, allowing the team to identify key themes, and to triangulate findings with other data from different tools and methods.

1.4.2 Online surveys

Two online surveys were conducted to gather evidence from farmers (Survey 1) and stakeholders (e.g., farmers, producer organisations and cooperatives); and public authorities (Survey 2) from the EU-27 (e.g. authorities responsible for water management and other operations) on CCA strategies, tools and practices. The surveys were designed, using insights from the qualitative scoping interviews, input from the Scientific Committee, and findings from the literature review. The surveys were shared with DG AGRI for feedback before finalising. Both surveys were drafted in English and translated into the respondents' national languages. The questionnaires contained between 10 and 30 questions, including both close-ended and open-ended questions. The surveys were programmed and disseminated via Forstra Plus, an online platform that allows to create, deploy, manage and analyse online surveys.

The study team developed a stakeholder map to identify organisations to support the dissemination of the surveys and increase reach to stakeholders and farmers operating in the EU, while trying to obtain representation from all agricultural sectors and MS. Respondents to the farmers survey were reached via farmer associations and organisations working with farmers who disseminated the open link via various communication channels (i.e., newsletters, organisation's websites). Stakeholders received an open link to directly respond to the survey. To ensure representation from all MS and sectors, the study team regularly monitored the distribution of responses and employed multiple measures² to ensure that a variety of views were captured.

The study sample reflects those respondents who were able and willing to take part, meaning that the results are not representative of the entire population.

Nonetheless, valuable insights were gathered from survey respondents on adaptation strategies, tools and practices implemented by a range of:

- Farmers, producer organisations/cooperatives and other relevant private-sector actors, and

² These measures included disseminating tailored communications to promote the survey, providing multiple reminders to complete the surveys and extending the fieldwork period.

- Public authorities (EU Member States/regional/local) NGOs, and research institutions.

The Stakeholder and Farmer surveys were launched on 30 April 2025 and 7 May 2025 respectively, and both were closed 4 July 2025. The stakeholder survey received 100 responses, and the farmer survey received 334 responses across the EU. A detailed breakdown of responses for both surveys is presented in Table 4 and Table 5.

Challenges and limitations

From its inception, the stakeholder survey had a low response rate. To address this, the survey team implemented multiple strategies, including simplifying the survey to reduce complexity and length, with these changes communicated to prospective participants. The team decided to retain key questions aimed at collecting information on adaptation strategies, tools and practices, and removed questions that were addressed through other research activities. Due to the simplification of the stakeholder survey while it was still live, the analysis included both the full sample and a subsample consisting of respondents who answered the open-ended questions, which were removed during data collection to enhance response rates. This subsample was mainly considered in response to SQ1, as explicitly indicated in the analysis (See section 2.1).

The primary challenge encountered with the farmer survey was an uneven distribution of responses across MS. There was notably a disproportionately large number of responses from Finland. Imbalances in the response sample are not unusual in surveys of farmers when their participation is not incentivised, and panels are not used or available (see for example the disequilibrium across MS in Albaladejo-Rodilla et al. 2025). To adjust for sample imbalances, a weighting coefficient was applied, based on the Utilised Agricultural Area (UAA)² for each MS. Applying a weighting coefficient mitigated the risk of findings being skewed by the most accessible or responsive subgroups, thereby minimising country-specific bias. It is important to note that there were no responses from certain MS, meaning that applying a weighting coefficient did not have an impact on these cases. Consequently, weighting did not address the issue of underrepresentation for these MS. Therefore, the uneven distribution of responses by country, coupled with the limited sample size, means the survey data is not fully representative and should not be generalised. This limitation must be considered when interpreting the survey results.

Weighting was applied only to survey questions Q23 and Q24, which concern the factors contributing to decisions to adapt or not to CC. These questions were weighted to account for the influence of national and local factors on farmers' decisions. Weights were not applied to the full dataset as sample sizes for key MS were too small relative to the population. Applying weighting in this instance would have substantially increased their influence on the overall statistics, thus impacting

negatively the reliability of the data. All presented data is clearly indicated as either weighted or unweighted.

Table 4. Demographic profile farmers survey (Counts n=)

	Total	AT	BE	HR	CZ	DK	FI	FR	DE	EL	HU	IE	LV	LT	PL	RO	ES	SE
Total	334	6	21	9	15	50	88	26	44	7	17	2	12	1	16	2	17	1
Agroclimatic zone (=n)	334	6	21	9	15	50	88	26	44	7	17	2	12	1	16	2	17	1
Coastal	40	0	9	2	0	14	8	0	4	0	0	0	1	0	1	0	1	0
Mountainous	9	2	0	2	1	0	0	0	1	0	0	0	0	0	2	1	0	0
Mediterranean	20	0	0	1	0	0	0	0	0	6	1	0	0	0	0	0	12	0
Boreal	93	0	0	0	0	0	82	0	0	0	0	0	9	1	0	0	0	1
Atlantic	47	0	1	0	0	18	0	22	4	0	0	2	0	0	0	0	0	0
Continental	130	4	9	6	14	18	1	5	35	1	17	0	1	0	12	2	5	0
Don't know	8	1	2	0	0	1	1	0	1	0	0	0	1	0	1	0	0	0
Produce type (=n)	334	6	21	9	15	50	88	26	44	7	17	2	12	1	16	2	17	1
Crops	191	4	7	3	5	24	58	24	16	3	13	0	8	0	9	0	16	1
Livestock	39	1	2	0	1	3	16	0	12	0	0	1	1	0	0	2	0	0
Both	86	0	11	3	8	22	14	1	12	2	2	0	3	0	7	0	1	0
Other	18	1	1	3	1	1	0	1	4	2	2	1	0	1	0	0	0	0
Gender (=n)	334	6	21	9	15	50	88	26	44	7	17	2	12	1	16	2	17	1
Male	267	5	16	5	12	49	64	19	38	6	13	2	9	1	12	1	14	1
Female	52	1	4	4	0	1	16	5	6	1	4	0	3	0	4	1	2	0
Non-binary	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Prefer not to say	13	0	1	0	3	0	8	1	0	0	0	0	0	0	0	0	0	0
Age (=n)	334	6	21	9	15	50	88	26	44	7	17	2	12	1	16	2	17	1
Under 35 years	23	1	0	1	1	1	7	3	1	1	1	0	3	0	1	0	2	0
35-44 years	52	1	5	2	3	3	17	4	7	3	2	0	0	0	3	1	1	0
45-54 years	81	3	8	2	5	5	16	7	10	2	7	1	4	0	6	1	3	1

	Total	AT	BE	HR	CZ	DK	FI	FR	DE	EL	HU	IE	LV	LT	PL	RO	ES	SE
55-64 years	119	0	5	4	5	24	28	11	21	1	1	0	4	0	6	0	9	0
65 years and over	51	0	3	0	1	17	14	0	5	0	6	1	1	1	0	0	2	0
Prefer not to say	8	1	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	0

Table 5. Demographic profile stakeholders survey (Counts n=)

	Total	A T	B E	C Y	C A	D K	E E	F R	D E	E L	H U	IE	IT	L V	L T	N L	P L	P T	R O	E S	S E
Total	100	3	10	1	1	2	1	11	5	3	2	1	4	2	7	5	22	6	7	5	2
Organisation type (=n)	100	3	10	1	1	2	1	11	5	3	2	1	4	2	7	5	22	6	7	5	2
Non-Governmental Organisation (NGO)	10	1	5	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1
Business association	9	0	1	0	0	1	0	1	0	0	0	1	0	0	1	2	0	0	0	2	0
Private company	14	1	0	0	0	1	0	1	2	0	0	0	0	2	1	0	1	1	4	0	0
Trade union OR professional association	8	1	2	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	1	0	0
Public body	32	0	0	1	1	0	0	4	2	0	1	0	2	0	3	0	13	2	1	1	1
Research/technical institute	12	0	0	0	0	0	0	1	0	1	0	0	1	0	0	2	4	1	0	2	0
Other	15	0	2	0	0	0	1	1	1	1	1	0	1	0	1	1	4	1	0	0	0
Sector of supply chain (=n)	31	2	3	0	0	2	0	5	2	0	0	1	0	2	2	2	1	2	5	2	0
Food producers	21	2	3	0	0	2	0	3	0	0	0	1	0	1	1	2	0	1	4	1	0
Food manufacturers	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Retailers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Farming advisors	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Veterinarians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Study on climate change adaptation in agriculture in the EU, with a focus on water management

	Total	A T	B E	C Y	C A	D K	E E	F R	D E	E L	H U	IE	IT	L V	L T	N L	P L	P T	R O	E S	S E
Suppliers to the farming sector (e.g. machinery, equipment, seeds, etc.)	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Lender / Financial Service Provider	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	6	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	1	1	0
Geographical remit (=n)	100	3	10	1	1	2	1	11	5	3	2	1	4	2	7	5	22	6	7	5	2
International	14	1	4	0	0	0	0	1	2	1	0	0	0	0	1	1	3	0	0	0	0
All-EU	8	0	5	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0
Multiple Member States	5	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0
National	44	0	0	1	1	1	1	6	0	2	2	0	2	1	5	2	10	4	2	2	2
Regional	17	0	0	0	0	1	0	3	1	0	0	0	1	1	1	0	3	2	2	2	0
Local	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2	1	0
Other	3	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
Agricultural sector (=n)	73	3	8	1	1	2	0	9	4	1	1	1	2	2	6	2	14	4	7	3	2
No specific focus	13	0	1	0	0	0	0	3	1	0	0	0	0	0	0	0	7	0	0	1	0
Crops	35	2	2	1	1	2	0	4	2	1	0	1	0	2	4	2	3	3	3	1	1
Livestock	32	1	4	1	1	2	0	2	2	1	0	0	1	0	5	1	3	3	2	1	2
Other	11	0	4	0	0	0	0	2	0	0	1	0	1	0	0	0	1	2	0	0	0

1.4.3 Focus groups and workshops

Two online workshops, one in-person focus group, and one hybrid focus group were conducted. These activities were organised to define the scope of the research, gather evidence in response to the various SQs, and validate findings. Specifically, the study team conducted a:

- **Scoping focus group (In-person):** This focus group took place on 4th March 2025 in Brussels, and its purpose was to collect data on good practices, gaps and controversies on strategies, tools as well as changes in farming practices linked to climate impacts, and to gather evidence on water resilience to prioritise further data collection and analysis. 12 participants attended representing various organisations, including farmers' organisations and co-operatives, EU-level organisations with expertise on water and climate, representatives of cooperative banks.
- **Online workshop with experts:** This workshop took place on 20th May 2025. The purpose was to validate the inventory, assess the main factors that determine the suitability of practices, and discuss how to integrate long-term transformational water management approaches into the inventory. 17 participants attended the online workshop. The group included three regional or provincial public authorities, one river basin authority, four NGOs, two sectorial organisations, four farmer groups and producer organisations, one private sector actor, three research institutions and two academic experts. Participants included agricultural advisors, scientific assistants and researchers specialising in climate change adaptation, irrigation engineering and water-soil-climate nexus approaches.
- **Online workshop with stakeholders:** This workshop took place on 28th August 2025. The purpose of this workshop was to discuss agricultural resilience to water-related CC impacts and the role of the CAP and other funds in this context. It also focused on the coordination between CAP support and the implementation of the WFD to avoid maladaptation. 35 participants attended the discussion. The group included two regional or provincial authorities, six river basin authorities, fifteen sectorial organisations, four NGOs, four research institutions, five academic experts, one farmer organisation, and one private sector actor. The areas of expertise covered were agriculture, irrigation, water management, climate change adaptation, and AKIS.
- **Validation focus group (hybrid):** This focus group took place on 1st October 2025 in Brussels, and its main objective was to validate the gaps and shortcomings identified by the study team regarding strategies to adapt agriculture to CC and enhance water resilience. The main findings were presented and discussed to explore how these challenges can be addressed at regional, local, and sectoral levels, both through the CAP and other measures. To maximise participation, this research activity was conducted in a hybrid format. 13 participants attended the group discussion. The group included four regional or provincial authorities, two river basin authorities, three sectorial organisations, two EU-level bodies, one NGO, and one farmer

association. Participants included representatives from ministries of agriculture and forestry, regional departments of agriculture and water agencies, as well as EU-level irrigation networks.

1.4.4 Case studies

The objective of this activity was to collect qualitative and quantitative information on adaptation strategies, practices, policies and tools implemented at regional level addressing water related challenges in response to all SQs. As part of this assignment, the study team conducted five (5) case studies (CS) in Pays-de-la-Loire (FRG) / France, Catalonia (ES51) / Spain, Emilia-Romagna (ITH5) / Italy, Upper Austria (AT31) / Austria and Wielkopolskie (PL 41) / Poland.

The case studies were selected based on four criteria:

- **Agroclimatic regions:** Selection of four main agroclimatic area covering the EU which are: Mediterranean, Atlantic, Continental and Mountain.
- **Diversity of agricultural production:** Focus on important regional agricultural productions in terms of agricultural output as they may face increased exposure to water-related climate events.
- **Water management policies and adaptation strategies:** Primary identification of the implementation of public policies and adaptation strategies at national or regional or river basin level.
- **Complementarity to ongoing case studies by DG AGRI:** To ensure that chosen case studies cover either additional sectors and/or climate impact and/or biogeographic region.

Each case study encompassed around 15 on-site interviews, desk research including stakeholder mapping, data analysis, and reporting. The case studies captured the complex interactions among various policies, systems, stakeholders, and levels of governance. This structured approach helped bridge data and information gaps, validate findings, and make results more robust. The case study implementation included 81 interviews involving 106 participants, of which 60 were conducted on-site.

The case studies interviews focused on regional agricultural authorities, water basin authorities, agricultural (chamber of agriculture, co-operatives) and other stakeholders (university and NGOs), and farmers who have implemented changes in farming practices to adapt to water related CC impacts. Once the interviews were carried out, data was analysed, triangulated and reported in case study reports which include the following analysis:

- **Agricultural, hydrological and institutional context of the region:** An overview on the main regional agricultural production landscape, the hydrological patterns of the region, the main CC impacts on agriculture and the characteristics of the institutional landscape concerning water and agriculture.

- **Analysis of CCA strategies and tools and farming practices:** Strategies implemented to address water-related CC impacts in the agri-food sector at national, regional or water basin or sectoral level. Providing an overview of the tools and changes in farming practices deployed to adapt to CC. Additionally, the main drivers and barriers faced by farmers to change are also included.
- **Focus on three adaptation farming practices aiming at increasing water resilience:** Documenting the implementation, level of uptake, drivers and barriers, costs, and benefits and scalability of the three selected adaptation practices implemented.
- **Role of CAP instruments and other public and private instruments:** Exploring the role played by mandatory requirements and CAP instruments and other instruments supporting adaptation of agriculture to CC. Highlighting information of synergies, contradictions and levers to improve water resilience of agriculture.

An overview of the five case studies carried out under this assignment, including the specific farming practices analysed, is presented in Table 6.

Table 6. Overview of the five case studies carried out under this assignment

Country	Region	Sector studied	CC water related impacts addressed	Farming practices analysed
France	Pays de la Loire	Livestock farming - bovine dairy and meat cattle	Excess of water Water scarcity Extreme temperature	Agroforestry and hedgerows plantation Seasonal calving for fodder management and one milking per day
		Crop farming - greenhouse and open-field vegetable	Water scarcity	Basins for rainwater collection in vegetable greenhouses and reuse for efficient irrigation system
Spain	Catalunya	Livestock farming - pig	Water scarcity	Basins for rainwater collection and reuse in pig farms
		Crop farming - fruits and wine	Water scarcity	Cultivation of drought-resistant grafted rootstocks
		Crop farming - cereals and wine	Water scarcity	Inter-row cover and reduce tillage in vineyard and cereal crop cultivation
Italy	Emilia-Romagna	Crop farming - open field vegetable production	Water scarcity	Drip irrigation supported with soil sensors and Drive Support System (DSS)
		Crop farming - open-field tomato production for industry	Water scarcity	Improving soil organic matter with biochar
		Livestock farming - bovine dairy	Water scarcity	Conservation agriculture in dairy farms producing Parmigiano Reggiano PDO in mountainous area
Austria	Upper Austria	Livestock farming - bovine dairy and meat cattle	Droughts and heavy precipitation events	Drought tolerant forage species Grass species resistant to water stress and permanent soil cover
		Livestock farming - bovine dairy and meat cattle and crop farming - cereals	Droughts and heavy precipitation events	Improving soil organic matter with reduced tillage
		Livestock farming - bovine dairy and meat cattle	Droughts and changed precipitation patterns	Water ponds to collect rainwater and use it for watering
Poland	Wielkopolska	Livestock farming - meat cattle Crop farming - cereals	Water scarcity	Improving soil organic matter with reduced tillage
		Livestock farming - meat cattle Crop farming - cereals	Heavy rains, Water scarcity, droughts	Water ponds to collect rainwater and using it for irrigation
		Livestock farming - meat cattle Crop farming - cereals	Water scarcity	Introducing new species of crops less sensitive to water scarcity including sorghum forage

2 Findings

2.1 SQ1: What strategies, tools as well as changes in farming practices have been developed and implemented in EU agriculture to adapt and build resilience to CC, including water related climate impacts?

281 changes in farming practices, 30 strategies and 30 tools have been identified as being developed to respond to CC impacts in the EU, although the lists of strategies and tools are not exhaustive. The measures identified utilise several mechanisms, including altering the choice and selection of species, breeds and varieties; increasing diversification, desynchronisation and external risk management; bolstering the resilience of plants; improving protections of livestock, crops and harvests from extreme weather; stockpiling, increasing equipment capacity, and autonomy; and lastly, relocation. Measures specifically aimed at increasing water resilience can be categorised as those that reduce water demand, increase water use efficiency, enable water reuse, or extend water supply. Data on the implementation of the various changes in practice, tools and strategies is fragmented if existent, but two surveys and an expert consultation have elucidated some general trends in level of implementation, with practices aimed at improving the health and water retention capacity of soils as particularly prominent.

2.1.1 SQ 1.1 – By farmers, producer organisations/cooperatives and other relevant private-sector actors?

Characterisation of adaptation practices

As described in section 1.3.2, the study team conducted a systematic review of secondary data and developed a comprehensive inventory of farming practices to adapt and build resilience to CC threats in the EU. A total of 281 changes in farming practices, 30 strategies and 30 tools were documented in the inventory based on the analysis of sources including AgriAdapt, CAMBIA library and academic literature. The findings presented in this section are drawn from the systematic review of secondary data and the development of the inventory of practices.

Choice and selection of species, breeds, varieties

A key approach to improving resilience in agricultural systems under climate stress is the **strategic selection of species, breeds, and varieties of crops** better adapted to emerging or anticipated climatic conditions. These practices leverage existing genetic diversity to reduce vulnerability to a range of climate-related

stressors, including heat, drought, frost, salinity, and shifting pest and disease pressures (AWA AgriAdapt 2020; Madrid et al 2025).

Inventory sub-categories covered	Practices in each category
Choice of crops/varieties	i) Blocking of maturities, ii) choice of cultivars / rootstocks of vigorous deep roots, iii) choice of halophytic crops or with high salt tolerance, iv) choice of rootstock, v) choice of disease-resistant varieties, vi) crop substitution, vii) cultivation of late ripening varieties, viii) combining grafting and rootstocking, ix) introduction of foreign varieties adapted to local climate conditions, x) diversification of forage tree species and increase of intraspecific diversification in "dehesas", xi) native varieties, xii) perennial cereals
Breed / species	i) Extending the productive lifespan of cows, ii) breeds / species selection based on thermotolerance, iii) selecting breeds with lower fodder consumption

In livestock systems, farmers may opt for breeds with greater thermotolerance to mitigate the negative impacts of heat stress, improve animal welfare and productivity (AWA AgriAdapt 2020; Madrid et al 2025). Selection processes can also prioritise animals with lower feed requirements, thereby easing pressure on fodder resources.

In crop production, an array of adaptations aim to align plant traits with evolving environmental conditions (European Commission 2016). For example, in areas prone to late frosts, farmers may shift to varieties with greater resilience in secondary bud development or later-maturing varieties which may also avoid peak heat during critical stages of crop development. In regions facing intensified salt stress, for instance from coastal saltwater intrusion, salt-tolerant species or varieties can be considered. Perennial crop producers may respond to climate stress by adjusting the choice of rootstocks and plant material adapted to new thermal and rainfall regimes, and resistant to soil-borne pathogens, to achieve long-term resilience and fruit quality.

An analysis of AWA- AgriAdapt data (2020) shows that both native and foreign plant genetic resources may be considered. Native varieties, long adapted to local agro-ecological conditions, may be used to select traits conducive to resilience to shocks already experienced in the past in local areas (*terroir*). Varieties from regions experiencing similar or harsher conditions may also be adopted for adaptation, in the hope that they may grow in a new *terroir* while carrying traits (e.g. resistance to pests, heat, drought) acquired previously. In forage systems, drought-tolerant species such as alfalfa, trefoil, or tall fescue are being adopted, in parallel with the introduction of resilient forage tree species within silvo-pastoral systems³ (e.g., 'dehesas'⁴).

At a systemic level, improved and updated seed banks can help ensure that farmers continue to have access to resilient planting material. Even downstream processes

³ Sylvopastoralism is an agroforestry practice that integrates trees, forage, and livestock on the same land.

⁴ A dehesa is a traditional Iberian agrosilvopastoral system – a land-use practice combining trees, grasslands, and extensive livestock farming – found in southern Spain and Portugal (known as montado there).

can facilitate the adaptation of agri-food supply chains. In viticulture, the selection of new yeast strains better suited to altered grape chemistry and fermentation under warmer conditions is one way in which the wine production process adapt to climate-induced changes (De Leo et al 2024).

Diversification, desynchronisation and external risk management

Another set of adaptation measures identified in the inventory relate to **diversification, desynchronisation and external risk management**.

Inventory sub-categories covered	Practices in each category
Insurance	i) Damage-related insurance, ii) index-related insurance, ii) insurance against production risks, iv) mutual funds, v) weather derivatives
Crop rotation	i) Crop rotation, cultivation of legumes (within the crop rotation), ii) expansion of crop rotation, iii) integrating multi-species pastures into the crop rotation, iv) very diversified rotation, v) planning crops to optimize harvesting sequence
Crop timing	i) Timing phenological development to avoid summer heat and droughts, ii) adapt date of sowing & variety precocity, iii) planning crops to optimize harvesting sequence
Diversification / desynchronization	i) Diversify grape varieties, ii) diversifying the bouquet of species and varieties to desynchronise sensitive crop stages, iii) limit the area sown by variety, iv) mixing of sowing dates for the same crop
Fodder management / grazing (in relation to diversification and desynchronisation)	i) Cover crops for fodder, ii) diversify forage components, iii) dual purpose crops, iv) forage hedges, v) grassland renewal, vi) halophytic forage crops for cattle, vii) legumes in grassland, viii) mixture of forage crop varieties, ix) multi-species grasslands, x) sorghum forage, xi) use of byproduct feed

Measures of **diversification** of production systems impacted by CC, including extreme weather events and the impacts of increased pests and disease were identified in the literature (Zonneveld, Turmel and Hellin 2020). A balance of species, crops or production cycles that have distinct strengths and vulnerabilities can limit exposure to specific climate risks. Such climate-informed diversification can help reduce the scale of the losses that may result from climate-induced events, with successful productions compensating for unsuccessful ones (De Leo et al 2024). Such risk-spreading has been designed for a variety of contexts, including cropping systems, livestock feed strategies and insurance-based instruments.

An exploration of the AWA- AgriAdapt (2020) shows that at farm level, **diversification** may take the form of cultivating a greater range of crops within a single year. Within forage systems, farmers may introduce a wider range of varieties or fodder components or opt for dual-purpose crops such as corn or wheat that can be used for food or feed, depending on seasonal conditions (Rouillé 2018). Similarly, cover crops or catch crops can serve the dual role of protecting the soil and building up fodder reserves during periods of shortage. In perennial systems, the diversification of tree or grape varieties may offer comparable risk-buffering effects (De Leo et al 2024). **Desynchronisation** practices are closely related to diversification. They aim to reduce the likelihood that critical crop stages (e.g.

flowering, ripening) will all happen at the same time by adverse weather. This is achieved by mixing sowing dates within the same crop or selecting a set of species and varieties with differing maturation profiles. Planning the harvest sequence to match expected weather windows is another related approach. Mixing multiple varieties within the same plot, particularly on more climate-sensitive parcels, can also contribute to spreading risk across different physiological responses (De Leo et al 2024; Morel and Cartau, 2023).

External risk management tools such as crop insurance and weather-based financial instruments are considered as additional buffers. Insurance schemes can be structured around either production risks or regional and weather indices. Weather derivatives, based on specific meteorological indicators like rainfall or temperature, offer more targeted options. Farmers may use such financial tools to help stabilise income flows where climatic hazards affect farm-level outputs (Hambruch et al 2020).

Bolstering the resilience of plants

To support **plant resilience** under changing climatic conditions, farmers may rely on soil-enhancing practices and input strategies that optimise nutrient uptake, stabilise yields, and reinforce root development.

Inventory sub-categories covered	Practices in each category
Farming system change	i) Natural Sequence Farming (NSF), ii) organic agriculture, iii) precision farming, iv) vertical farming
Crop combination	i) Creation of a varietal bouquet on the farm, ii) crops diversification > 5 crops at farm level, iii) crops diversification at farm level (3-5 crops), iv) intercropping, v) mix of varieties within plots more sensitive to climate stress (cold, drought...).
vi) Nutrients	i) Application of fertilizers in increments, ii) fertirrigation, iii) foliar fertilization, iv) liquid manure management, v) locally placed fertiliser, vi) optimal nutrient supply, vii) regular application of organic fertilizers
Cover	i) Change crop rotation to ensure longer soil cover, ii) cover crops, iii) cover soil with straw or stubble to avoid bare soils in summer, iv) covering of ridge plantings, v) cultivation of diverse catch crop mixtures, vi) green manure fallows, vii) inter-row cover, viii) low mulching of driving lanes, ix) plastic mulching, x) biodegradable mulching, xi) natural mulching, xii) BRF (Bois Raméal Fragmenté)
Tillage	i) Minimum tillage, ii) no-till farming / direct seeding, iii) reduced tillage, iv) shallow soil tillage, v) strip tillage, vi) subsoiling if a hard pan is present, vii) vertical tillage, viii) very shallow soil tillage
Organic content	i) Biodegradable mulching, ii) natural mulching, iii) ash, iv) biochar, v) compost, vi) composting of organic material, vii) digestate use, viii) green manure with brassicaceae, ix) green manure with nitrogen-fixing crops, x) leaving crop residues on the field, xi) manure, reuse of green waste in fields, xii) reuse of wood chips in fields, xiii) slurry with eco-sustainable practices (injected into the ground), xiv) vermicompost, xv) BRF (Bois Raméal Fragmenté)

Inventory sub-categories covered	Practices in each category
Traffic	i) Controlled traffic system, ii) covering of the driving lanes, iii) delayed creation of driving lanes, iv) driving on the field only in dry conditions, v) lighter machines to reduce compaction, vi) self-driving machines, vii) tyre pressure regulation systems as a contribution to soil protection
Porosity	i) Rock flour, ii) water infiltration by earthworm introduction and management
Drainage	i) Closed drainage systems, ii) controlled drainage, iii) improvement of soil drainage, iv) sustainable intensification of drainage
Other (in relation to crop resilience and soil management)	i) Biostimulants, ii) cultivator, iii) grazing for interrow weeding, iv) mycorrhizae, v) optimize growth regulators and -stimulators, vi) relay cropping, vii) soil rehabilitation

Numerous measures aim to maintain or restore the biological, chemical, and physical health of soils, such as targeted application of organic fertilisers, the use of ash or rock flour as nutrient, and the incorporation of green manure crops. Practices such as foliar fertilisation during drought, the use of mycorrhizae to accelerate root development, or biochar application to enhance nutrient and water retention may further strengthen plants' ability to sustain growth under stress. Practices such as intercropping and relay cropping seek to improve agroecosystem function by diversifying nutrient use strategies and improving microclimate resilience, while also supporting weed and pest control (AWA AgriAdapt 2020; De Leo et al 2024; European Commission 2016). Organic farming systems integrate many of these practices by design

Protecting livestock, crops and harvests from extreme weather

A range of practices to mitigate CC impacts on livestock and cropping systems through physical protection, reducing exposure and enhancing capacity to tolerate were identified through the inventory analysis.

Inventory sub-categories covered	Practices in each category
Heavy rain protection	i) Multifunctional nets: anti-cracking, anti-insect, ii) rain protection and anti-cracking cover, iii) greenhouses
Hail protection	i) Hail protection nets, ii) tempered glass in glasshouses, iii) multifunctional nets: anti-hail, anti-cracking, anti-insect, iv) foil roofs
Labour protection	i) Harvest at night
Harvest protection	i) Additives for high-moisture cereal conservation for animal feed, ii) cooling of the grape harvest (solid co2)
Fodder management / grazing (in relation to grazing management)	i) Adapted grazing management, ii) adapted silage measures, iii) adapting the cutting depth, iv) drought tolerant forage species, v) dynamic grazing, vi) promote semi-natural spaces, vii) reduced cutting and fertilising of grassland, viii) rotational grazing, ix) seasonal calving for fodder management, x) stock of standing grass, xi) timing of grassland management, xii) transhumance
Conditioning animals to higher temperatures	i) Implement early embryonic conditioning of chicks (e.g., brief exposure of eggs to controlled heat stress can help improve their heat tolerance)
Livestock density	i) Adapting to fodder shortages, ii) adjust animal stocking density, iii) maintain smaller colonies

Inventory sub-categories covered	Practices in each category
Temperature management (livestock) (except in relation to backup generators)	i) Active ventilation in buildings, ii) adapt diet content, iii) adaptation of the feeding time, iv) adaptation of the grazing time, v) adapted animal transport times, vi) adjust calving periods to avoid heat stress, vii) artificial shelter in fields, viii) avoiding heat stress during sensitive reproduction periods, ix) manipulation of the rumen ecosystem, x) natural shading of buildings, xi) natural shelter in fields, xii) one milking per day, xiii) optimizing feed intake under high temperature conditions, xiv) passive barn cooling, xiv) photovoltaic system on the roof, xvi) quality watering, xvii) reduce animal density in buildings, xviii) roof greening, xix) roof sprinkling, xx) sprinklers in stables, xxi) sufficient drinking troughs
Feed (e.g., adding water to feed, using supplementation or forages of higher nutritional value during periods of high heat)	i) Adding water to the ration, ii) increasing the use of supplementary feeding, iii) mineral and other feed additives, iv) modification of the nutritional intake of cattle, v) provide plant extracts to reduce digestive inflammation, vi) stabilisation of feed mix rations, vii) use forages of higher nutritional value during periods of high heat
Pests and diseases protection (livestock)	i) Optimized hygiene, ii) upgrade biosecurity measures
Frost protection	i) Anti-freeze fans, ii) anti-freeze over-tree irrigation, iii) anti-freeze products to apply to the plants, iv) anti-freeze spark plugs and burners, v) anti-freeze under-tree irrigation, vi) anti-freeze-fan rotary system from the ground, vii) anti-frost candles, viii) electric heating systems, ix) higher trunks, x) mobile gas turbines, xi) other anti-frost air remixing systems, xii) selecting frost-resilient varieties, xiii) greenhouses
Temperature management (crops)	i) Agrovoltatics, ii) bunch clearing, iii) cellar insulation, iv) filter nets for shading, v) kaolinite - application on leaves, vi) late winter pruning, vii) leaf management, viii) over-tree cooling irrigation, ix) passive cooling of tunnel greenhouses, x) change of the technique of green pruning (canopy management), xi) pruning during growth period, xii) reduced summer pruning, xiii) foil roofs
Wind protection	i) Greenhouses, ii) stabilisation of the plantation facilities
Pest and disease protection (crops)	i) Multifunctional nets: anti-hail, anti-cracking, anti-insect, anti-insect nets, ii) preparedness for earlier application of crop protection, iii) pruning and vine management after extreme weather events
Product processing	i) Acid must, ii) coupage of different wines/varieties, iii) membrane technologies, iv) new yeast strains for fermentation, v) source grapes from cooler areas, vi) wine yeasts
Other (in relation to crop protection)	i) Minimal pruning

CC impacts on livestock can be mitigated by protecting animal welfare and health during critical periods, through microclimate management, nutritional adjustments, and protective infrastructure. These include temperature management measures such as implementing active (fans, sprinklers) and passive (shaded feeding areas, roof greening, and natural tree shading) cooling methods to reduce heat stress, adjusting stocking densities, optimising transport times, and modifying calving or reproduction schedules to avoid the hottest months. Fodder/ grazing management, and feed measures can aim to maintain livestock health and productivity during heat stress by adding water to feed, adjusting feeding times, using digestible fibre, or providing antioxidants, minerals, and live yeasts to support digestion. Salt and potassium aid hydration and heat regulation, while high-quality forages and nutrient-rich feeds sustain intake. Additives and enzymes improve palatability and reduce spoilage (AWA AgriAdapt 2020; CNIEL 2020; De Leo et al 2024; Madrid et al 2025).

In **crop production**, a range of temperature management practices aim to protect plants from heat and cold extremes. Anti-frost systems (i.e., fans, irrigation, spark plugs, candles, or thermal screens) may be used to counter late frost events. Conversely, shading techniques, leaf management, pruning strategies (e.g. controlling growth to optimise water use or to exploit favourable weather windows), kaolinite sprays, and temperature-regulated greenhouses can be used to protect crops from solar radiation and excessive heat. Filter nets, roof sprinkling, photovoltaic systems, and temperature-regulating tunnels can reduce plant stress. For post-harvest protection, practices like cooling grapes with solid CO₂ and reinforcing cellar insulation can help maintain product quality under elevated temperatures (De Leo et al 2024; Morel and Cartau 2023).

Stockpiling, increasing equipment capacity, and autonomy

Several adaptations aim to strengthen the farm's operational autonomy and resilience by improving self-sufficiency and buffering capacity. These include increasing on-farm storage capacity to enable strategic stockpiling of feed and inputs or enhancing machinery capacity to achieve more fieldwork or harvest during shorter weather windows. Farmers may also install backup power generators to protect livestock welfare and preserve stored produce during power outages in extreme weather conditions. In parallel, farmers may seek to reduce their vulnerability to climate-induced supply chain disruptions by replacing imported protein supplements with regionally sourced alternatives (e.g. substituting soybean with peas or rapeseed) or increasing on-farm forage production, fostering markets for local production (AWA AgriAdapt 2020; European Commission 2016; Madrid et al 2025; Morel and Cartau 2023).

Inventory sub-categories covered	Practices in each category
Business strategy	i) Change in wine profile, ii) CSA, iii) diversify production, iv) focus on quality production instead of quantity, v) fodder/manure or grassland cooperation, vi) increase machine capacity, vii) reducing fruit quality standards
Stockpiling	i) Improvement of seed bank stocks
Fodder management / grazing (in relation to external feed dependency)	i) Contractualisation of forage areas, ii) corn straw, iii) fodder stocks and portioning, iv) grain production autonomy, v) increasing storage capacity, vi) replace imported protein supplements with regional proteins (soybeans with peas or rapeseed), vii) solar drying of fodder
Temperature management (livestock) (in relation to backup generators)	i) Install backup power generator

Relocation

Often seen as a last resort, farmers can **relocate** production either in part or in whole to a higher altitude or to cooler areas to avoid the impacts of heat stress. This is particularly relevant for vineyards which are producing acidic or aromatic wines

(AWA AgriAdapt 2020; De Leo et al 2024). These adaptations require advice, training and high investment.

Scale and prevalence of implementation

Currently, all EU MS have set out national adaptation policies (Sardelli 2025), and most MS have identified agriculture as a priority within their national adaptation strategies or plans (EEA 2025). Despite the existence of numerous measures and programmes to facilitate adaptation, it remains uncertain how many individual farms across the EU have implemented climate-adaptation practices. Monitoring efforts are inconsistent and vary according to national policies, climate risk exposure, local capabilities, and funding accessibility (Quin 2023; Sardelli 2025).

In some cases, monitoring relies on general indicators (e.g., aggregated figures of irrigated cultivation terrain at the MS level) or total expenditure for CCA actions in the agricultural sector, which does not provide granular information on the actual practices of individual farmers. In some MS (e.g. Slovenia, Latvia), adaptation measures are often integrated into broader CC initiatives or long-term development plans, making difficult to quantify progress and funding dedicated solely to adaptation (European Commission 2025d). Consequently, available evidence regarding the level of implementation of CCA measures is currently insufficient for a thorough assessment. While some MSs have conducted assessments and evaluations of their adaptation plans (e.g., Germany, Netherlands, Austria), results reported tend to be aggregated at the policy level, rather than at the farm or impact level (e.g., current farm resilience, yield stability, number of farms implementing changes). The lack of comprehensive and comparable data presents a challenge and restricts the capacity to accurately assess the scale of implementation of adaptation initiatives in the EU.

The study team conducted a systematic review of secondary data to identify farming practices to adapt and build resilience to CC threats in the EU context, which were then classified and compiled into a comprehensive inventory of farming practices as described in section 1.3.2. This study provides an analysis of the inventory of practices and a preliminary assessment of uptake conducted by the project's Scientific Committee and other experts in France, Spain, Estonia, Germany and Ireland. Based on this assessment, Table 7 summarises the practices which were marked as being widely implemented (practiced by 50% or more of relevant farmers according to the experts estimates). Some practices were marked as being *widely practiced* by two experts from different MSs, inferring enhanced confidence in the judgement of widespread uptake across more than one MS. Examples of practices categorised as *widely practiced* by multiple experts include sowing of native legume seeds into grassland to improve pasture quality, diversifying crops at the farm level, reducing dependency on external inputs and improving farm health; responding to periods of drought by reducing the cutting and fertilisation of grassland; building fodder reserves to support livestock in low-yield years and dividing them into manageable portions for more efficient use.

As seen in Table 7, most of the practices categorised as *widely practiced* were identified under the typology of 'Protecting livestock, crops and harvests from extreme weather'. 'Diversification, desynchronisation and external risk management' also included 6 practices identified as *widely practiced*, and a further 22 which were estimated to be practiced by a minority (between 10-49%) of farmers.

Table 7. Changes in practice in the inventory which have been estimated as *widely practiced* (50% or more of relevant farmers) within the country that the expert making the estimation is based in⁵

Typology	Practice name	Relevant experts' country
Choice and selection of species, breeds, varieties	Selecting breeds with lower fodder consumption	Ireland
	Cultivation of late ripening varieties	France
Diversification, desynchronisation and external risk management	Diversify forage components	Estonia
	Sowing native legumes in grassland	Ireland, France
	Timing phenological development to avoid summer heat and droughts	Ireland x2
	Use of byproduct feed	Ireland
Bolstering the resilience of plants	Application of fertilizers in increments	France x2
	Covering of the driving lanes	Ireland x2
	Crops diversification at farm level (3-5 crops)	France x2
	Driving on the field only in dry conditions	France
	Optimal nutrient supply	France
	Tyre pressure regulation systems as a contribution to soil protection	Germany
Protecting livestock, crops and harvests from extreme weather	Adapted grazing management	France
	Adapted silage measures	France
	Adapting to fodder shortages	Estonia
	Dynamic grazing	Estonia
	Natural shelter in fields	Estonia
	Optimized hygiene	France
	Promote semi-natural spaces	Ireland

⁵ **NB.** Practices presenting inconsistent expert judgement within the same MS were not included in this table.

Typology	Practice name	Relevant experts' country
	Quality watering	Estonia
	Reduced cutting and fertilising of grassland	Ireland, France
	Seasonal calving for fodder management	Ireland, practiced by a minority in France
	Stabilisation of the plantation facilities	Ireland x2
	Sufficient drinking troughs	Estonia
	Timing of grassland management	Ireland, practiced by a minority in France
	Upgrade biosecurity measures	Estonia
Stockpiling, increasing equipment capacity, and autonomy	Fodder stocks and portioning	Ireland, France
	Increasing storage capacity	Ireland, practiced by a minority in France
	Install backup power generator	Estonia

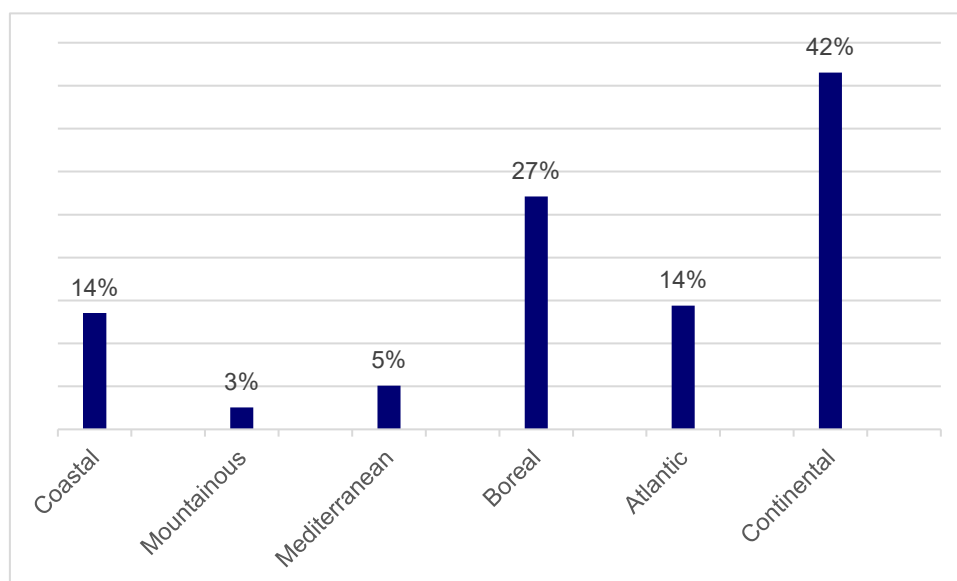
Results from the farmers survey (n=334) also provided an indication of the extent of implementation of specific measures. Survey respondents were asked to indicate their degree of engagement with CCA practices. 35%(n=118) of respondents stated having undertaken changes to their farming practices specifically to cope with future climate impacts, and another 40%(n=135) having considered doing so. Among those who reported implementing adaptation measures (35%, n=118)⁶, 80% (n=94) stated that their main production activity was crops (i.e., cereals, oilseeds, protein crops, horticulture, vineyards and olives) and 33% (n=39) produced livestock (i.e., dairy cattle, beef, poultry, and sheep, goats and other grazing livestock)⁷.

Some differences were observed regarding reported changes in farming practices by agroclimatic zones. For instance, the majority of farmers (69%) reporting the adoption of adaptation practices also indicated farming in continental (42%, n=49), and boreal (27%, n=32) agroclimatic zones (See Figure 2).

⁶ Farmers who took part in the survey and selected : "I have made changes to the way I farm specifically to cope with future weather problems" represented the following MS: Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Poland, Spain and Sweden. The remaining MS either did not take part in the survey or did not indicate to implement changes in farming practices in response to climate change. Please refer to the methodology section for more details on the farmers survey.

⁷ Survey respondents were allowed to select more than one option.

Figure 2. Proportion of farmers who selected: 'I have made changes to the way I farm specifically to cope with future weather problems' (n=118) by agroclimatic zone.



Q10. Farmers survey. Please select the statement that best describes your current situation: 'I have made changes to the way I farm specifically to cope with future weather problems' n=118 of 334. Unweighted. N.B. some farmers may have selected several agro-climatic zones, resulting in the sum of responses by agro-climatic zones exceeding the number of answers indicated for some entries

Those who reported implementing changes to their farming practices in response to climate challenges (35%, n=118⁸), were asked to select specific practices undertaken on their farm. Consistent with the findings from the inventory analysis and expert assessment, practices related to protecting livestock from extreme weather (i.e., reducing heat stress for livestock) and adapting grazing and fodder management were also identified by respondents to the farmers survey. Regarding crops, measures such as crop diversification and soil protection strategies (i.e., reduction of tillage, planting cover, and machinery pressure regulation systems as a contribution to soil protection) were also identified by both survey respondents and experts. The full list of practices most commonly adopted among survey respondents is presented in Figure 3.

Moreover, findings from the stakeholder survey⁹ offered an additional perspective on the level of implementation of specific practices by farmers within the stakeholder's organisation remit. In line with the findings from the farmers survey and expert assessment, a sub-set of the sample that took part in

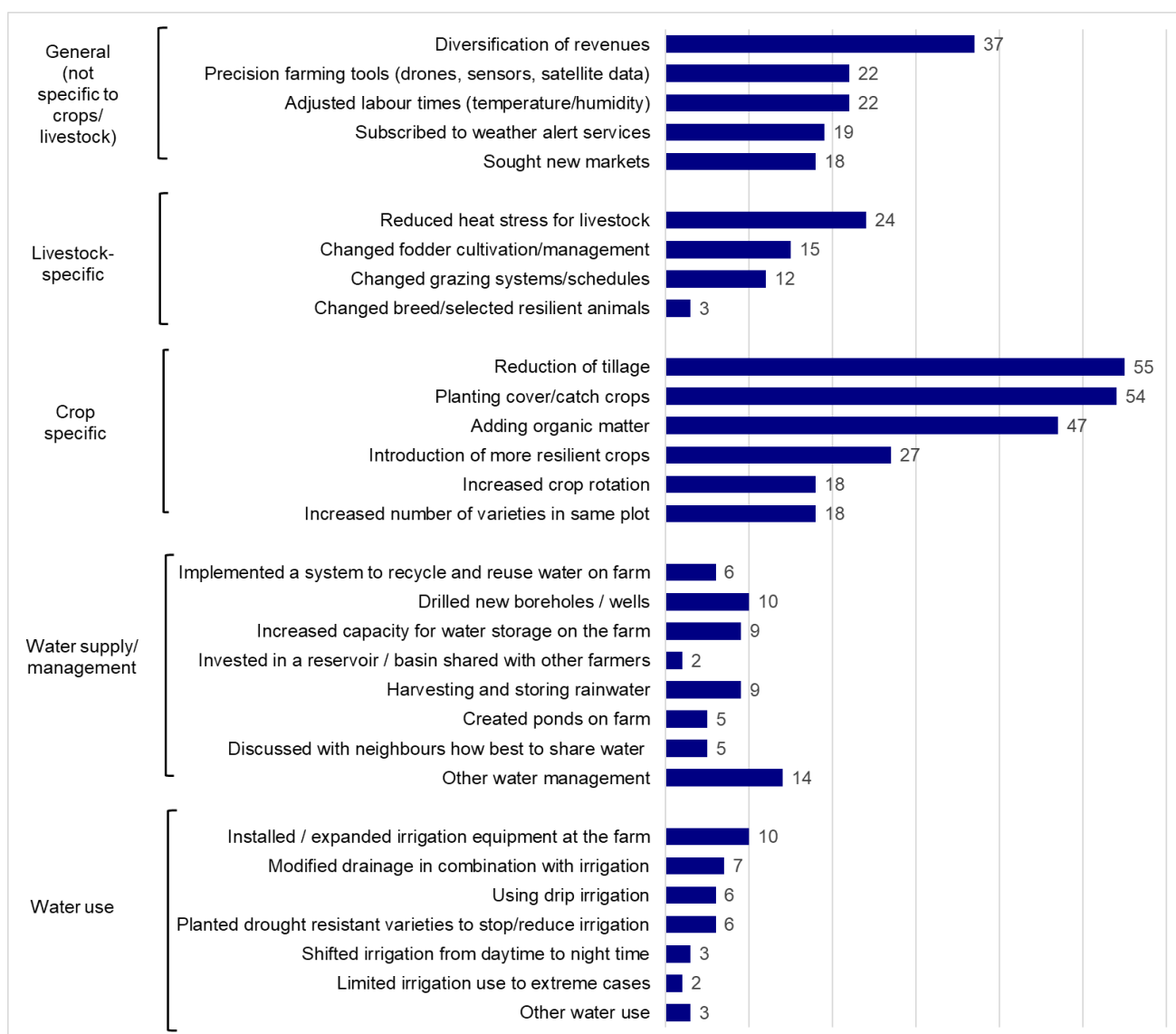
⁸ Farmers who took part in the survey and selected : "I have made changes to the way I farm specifically to cope with future weather problems" represented the following MS: Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Poland, Spain and Sweden. The remaining MS either did not take part in the survey or did not indicate to implement changes in farming practices in response to climate change. Given that not all MS are represented , these results are indicative rather than statistically representative of the population, and their generalisability beyond the respondent group is limited.

⁹ The stakeholder survey collected views from the following groups: Non-Governmental Organisation (NGOs), Business associations, Private companies, trade unions and professional associations, public authorities, Research/technical institutes.

the stakeholder survey¹⁰ (n=40) indicated that soil protection strategies (i.e., planting cover, adding organic matter such as mulching, compost and manure, and reducing tillage) were adopted by farmers in their remit. However, strategies related to livestock protection were not identified as widely adopted among farmers by this subgroup. Other strategies highlighted by stakeholders as widely implemented included using natural pest or disease control strategies and installing or expanding drip irrigation systems (see Table 8).¹¹

¹⁰ The sub-set of the sample represented the following sixteen MS: Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Portugal, Republic of Cyprus, Spain, Sweden.

¹¹ Stakeholders were presented with a list of high-level adaptation measures and asked to indicate which of these were being implemented by farmers within their organisation's remit. Where a practice was selected, stakeholders were then asked to rate the extent to which it was adopted using a 1–5 Likert scale ranging from "to a very large extent" to "to a very small extent/not at all". A numerical value was assigned to each response category: "to a very large extent" was allocated a value of 5, "to a large extent" a value of 4, "to a moderate extent" a value of 3, "to a small extent" a value of 2, and "to a very small extent/not at all" a value of 1. Each respondent's selection was then attributed its corresponding numerical value. For each statement, these values were summed and then divided by the total number of responses, to calculate the mean score. The formula used to calculate the mean score was: *Mean score = sum of response value / sum of responses*. This question was omitted from a later simplified, version of the survey, meaning that the analysis is based on a subset of respondents' data (n=40 stakeholders responded to this question).

Figure 3. Practices selected as adopted by respondents to the farmers' survey (Counts)

Q12 farmers survey: 'Please select the measures you have implemented' n=334. Unweighted.

Findings from the stakeholder survey¹² offered an additional perspective on the level of implementation of specific practices by farmers within the stakeholder's organisation remit. In line with the findings from the farmers survey and expert assessment, a sub-set of the sample that took part in the stakeholder survey¹³ (n=40) indicated that soil protection strategies (i.e., planting cover, adding organic matter such as mulching, compost and manure, and reducing tillage) were adopted by farmers in their remit. However, strategies related to livestock protection were not identified as widely adopted among farmers by this subgroup. Other strategies highlighted by stakeholders as widely implemented

¹² The stakeholder survey collected views from the following groups: Non-Governmental Organisation (NGOs), Business associations, Private companies, Trade unions and professional associations, public authorities, Research/technical institutes.

¹³ The sub-set of the sample represented the following sixteen MS: Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Portugal, Republic of Cyprus, Spain, Sweden.

included using natural pest or disease control strategies and installing or expanding drip irrigation systems (see Table 8).¹⁴

Findings from the stakeholder survey (n=100) also offered additional information on the potential reasons for the varying levels of uptake in their MS.

Stakeholders who reported¹⁵ having developed CCA practices (n= 36), tools (n=27) and/or strategies (n=39) were also asked to describe how widely these measures have been adopted by farmers in their remit and to explain the reasons for this level of adoption in an open-ended response. Overall, the majority of stakeholders reported that farmers have implemented strategies, tools and changes in farming practices to some extent, with only a minority indicating that adaptation measures have not been implemented at all (see Figure 4).

¹⁴ Stakeholders were presented with a list of high-level adaptation measures and asked to indicate which of these were being implemented by farmers within their organisation's remit. Where a practice was selected, stakeholders were then asked to rate the extent to which it was adopted using a 1–5 Likert scale ranging from "to a very large extent" to "to a very small extent/not at all". A numerical value was assigned to each response category: "to a very large extent" was allocated a value of 5, "to a large extent" a value of 4, "to a moderate extent" a value of 3, "to a small extent" a value of 2, and "to a very small extent/not at all" a value of 1. Each respondent's selection was then attributed its corresponding numerical value. For each statement, these values were summed and then divided by the total number of responses, to calculate the mean score. The formula used to calculate the mean score was: *Mean score = sum of response value / sum of responses*. This question was omitted from a later simplified, version of the survey, meaning that the analysis is based on a subset of respondents' data (n=40 stakeholders responded to this question).

¹⁵ Stakeholders were able to select more than one option.

Table 8. Adaptation measures most frequently observed by stakeholder survey respondents (n = 40) (Counts and mean score)

	(5) To a very large extent n=	(4) To a large extent n=	(3) To a moderate extent n=	(2) To a small extent n=	(1) To a very small extent/ not at all n=	Mean score †
Adding organic matter (e.g. mulching, compost, manure)	4	7	8	1	1	3.57
Planting cover / catch crops	5	4	6	2	4	3.19
Reducing tillage	3	5	8	3	2	3.19
Incorporating crop residues (stems, leaves, chaff, husks)	1	6	8	3	2	3.05
Using natural pest / disease control techniques	4	3	5	4	1	3.29
Use of different crop protection products	1	4	9	3	0	3.18
Lighter machines to reduce soil compaction	0	4	8	3	5	2.55
Investing in precision farming equipment	3	2	5	4	4	2.78
Increasing capacity for on-farm water storage	2	3	4	6	1	2.94
Harvesting and storing rainwater	1	4	5	5	1	2.94
Installing / expanding irrigation equipment	6	2	1	2	2	3.62
Changing the timing for spraying crop protection	4	1	6	1	2	3.29
Creating ponds on farm	2	4	4	2	3	3.00
Drip irrigation	4	2	4	2	1	3.46
Subscribing to a weather alert service	3	5	3	0	0	4.00
Reservoir / basin shared with other farmers	2	3	3	4	4	2.69
Diversifying crop rotation	0	4	8	1	0	3.23
Drilling new boreholes / wells	0	5	4	2	5	2.56
Changing farm traffic to reduce soil compaction	0	1	9	2	6	2.28
Crops more resilient to local conditions	0	4	5	4	1	2.86

Q14 Stakeholders survey: 'To which extent have the following adaptation practices been taken up by farmers in your remit?' † Mean response (1–5 scale), top 33% marked green. Base n=40 of 100 responses. Unweighted.

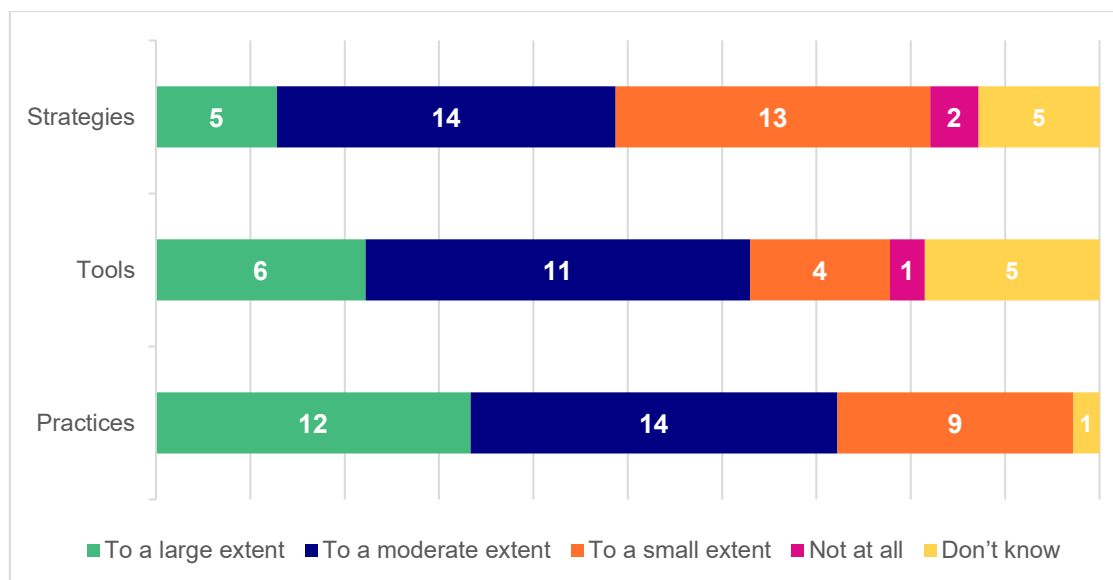
Findings from the stakeholder survey (n=100) also offered additional information on the potential reasons for the varying levels of uptake in their MS.

Stakeholders who reported¹⁶ having developed CCA practices (n= 36), tools (n=27) and/or strategies (n=39) were also asked to describe how widely these measures have been adopted by farmers in their remit. Overall, the majority of

¹⁶ Stakeholders were able to select more than one option.

stakeholders reported that farmers have implemented strategies, tools and changes in farming practices to some extent, with only a minority indicating that adaptation measures have not been implemented at all (see Figure 4).

Figure 4. Stakeholders' reported level of implementation of changes in practices, tools and strategies by farmers in their remit (counts)



Q6 Stakeholder survey. Have you or your organisation developed CCA practices, tools and/or strategies - please select all that applies to you. Base n= 100 responses. Unweighted.

Stakeholders were also asked to explain the reasons for the level of adoption of CCA measures among farmers in their remit in an open-ended response. The analysis of open-ended responses indicated that the uptake of adaptation measures is progressing on a small scale, at the local level, and is slowly expanding. An important point raised by stakeholders is that levels of uptake vary according to the territory, current climatic conditions, and actual risks observed on the ground. For example, stakeholders emphasised that the implementation of adaptation measures is strongly associated with specific climatic years, which in turn determine the scale and prevalence of individual adaptation measures from year to year. Table 9 presents a summary of the open-ended responses and outlines key factors contributing to the different levels of implementation reported by stakeholders.

Table 9. Summary of open-ended responses from stakeholder survey: Key factors contributing to varying levels of uptake

Level of uptake	Summary of open-ended responses (aggregated)
Low to moderate level of uptake	- Adaptation to CC consequences is costly: perceptions that investments in that matter do not yield economic benefits on the short term. Hence few farmers are willing to take the risk of that kind of investment without significant public and/or private (cooperatives) support. - Large scale implementation requires substantial financial resources and must take place in the medium to long term. EIP Agri intervention of the CAP take time to take effect. - Clear insight into the costs and benefits of measures is perceived as insufficient to inform farmers' decisions. - Minimisation of losses promoting uptake: implementation is ceased when the benefits are not evident. - Aging farming population finding investing in adaptation measures to be high risk. In some MS, such as Greece, the vast majority of farmers are over 55 years old with lower levels of engagement and interest in adopting changes. 'We think most of them are already giving up' - Limited knowledge, particularly from local research, to validate the economic, social, and environmental effectiveness of different technologies. Many farmers lack long-term awareness and vision for their farms, with most focused on short-term gains and often overlooking the potential future consequences of these decisions. - Lack of a strong position and vision of State institutions on these issues. - Adaptation practices are carried out at very local scale with farmers who are already willing to change, but planning is needed to replicate results on a large scale, including large landowners. In some cases, measures are staggered and deployed in stages, with slow expansion to other regions.
High level of uptake	- The implementation of selected solutions is facilitated by support from direct payments and EU projects - Subsidies and financial support: A large proportion of farmers introduce various environmentally friendly technologies because different forms of support are available, such as co-financing for the purchase of machinery, etc. As far as minimum tillage is concerned, some farmers have become more active in this practice, as this makes it possible to reduce costs and obtain a small amount of support in the form of subsidies. - Some sectors promote the uptake of adaptations more strongly than others: for instance, the European fish farming sector promotes innovation and adaptation measures are being widely implemented across the sector ranging from simple adjustments to highly complex interventions across the EU.

Q7a-Q9a Stakeholders survey. Please detail your understanding of why uptake [of practices, tools and changes in farming practices] has been at this scale [open text]. Coded. Base n=100

2.1.2 SQ 1.2 – By public authorities (EU Member States/ regional/local) and other relevant public actors?

The EEA's 2023 review found agriculture to be a good example of mutual mainstreaming between sectoral policies and adaptation policies: 22 MSs included CCA as a priority in their 2023–2027 CAP Strategic Plans, while 24 identified agriculture as a key climate-affected sector in their national adaptation plans (EEA 2023a). Integration has also advanced within water governance frameworks, through river basin and flood risk management plans, where over

half of MS now systematically consider climate impacts and increasingly align measures with national adaptation strategies, including through nature-based solutions (European Commission 2025a).¹⁷ However, one of the academic experts interviewed highlighted that coherence across sectors remains uneven, with some MSs demonstrating good cross-sectoral policy alignment while others continuing to pursue conflicting agricultural and water management objectives.¹⁸

Levels of governance involved

A range of public actors at different governance levels drive adaptation action. National governments set overarching frameworks through climate adaptation strategies and CAP Strategic Plans, while regional and local authorities translate these into concrete measures. By 2023, seven¹⁹ MSs reported having one or more regional adaptation plans in place (EEA 2023) with others, such as Germany's Brandenburg Federal State, recently adopting their own strategies (Brandenburg Ministry for Agriculture, Environment and Climate 2023). In countries like Italy, regional adaptation planning is mandatory, fostering closer alignment with local agricultural priorities. At municipal and landscape levels, local authorities also implement solutions, including through EU or nationally funded projects, piloting place-based solutions and supporting farm-level adaptation. Water management authorities also play a significant, if indirect, role by facilitating irrigation management and promoting efficient water use under changing climatic conditions. In parallel, research and technical institutions contribute to the development of knowledge, tools, and advisory systems that enable adaptive practices on the ground.

In some cases, public actors support bottom-up approaches that engage local stakeholders directly in adaptation planning and implementation. Examples include Flanders' *Blue Deal*²⁰, a comprehensive water management strategy that mobilises regional coalitions of local governments, farmers, businesses, nature organizations, and citizens to define area-specific objectives and implement concrete measures (Climate ADAPT, 2024). Similar approaches are observed in the Netherlands and in Germany, where water user associations facilitated (and funded) by water management authorities help farmers collectively manage irrigation under changing climatic conditions.²¹

¹⁷ The report notes, however, 'no evidence yet of a notable change on the ground in terms of large-scale uptake of nature-based solutions' and urges MS to increase their efforts to promote implementation.

¹⁸ Interview with expert/academia. The interviewee noted that at times sectoral plans may contradict one another, citing cases where agricultural plans seek to increase irrigation whereas water management plans envisage a reduction thereof. The expert noted Sweden, Latvia, Greece, Spain, and the Netherlands as positive examples.

¹⁹ Namely Belgium, Greece, Hungary, Ireland, Portugal, Spain and Sweden.

²⁰ See: <https://www.integraalwaterbeleid.be/nl/bluedeal>.

²¹ Interview with water management authority.

Typology of interventions employed by public actors

Public actors employ a diverse set of interventions intended to support the adaptation and resilience of agricultural systems to CC, including water-related impacts. These interventions span financial, informational, technical, and regulatory domains, and are implemented at national, regional, and local levels, often in combination. Broadly, they can be grouped into several categories: (i) **financial frameworks and investment**, including incentives, infrastructure projects, and insurance schemes to reduce climate-related risks; (ii) **education, information, and advisory support**, covering advisory services, decision-support tools, demonstration farms, and training initiatives that build farmers' knowledge and adaptive capacity; (iii) **risk management**, such as early-warning systems and response plans for droughts, floods, or other climate hazards; (iv) **regulation and monitoring**, which governs resource use, enforces compliance, and ensures sustainable management of water and land. Other interventions include mechanisms to facilitate stakeholder cooperation, coordination, and participatory planning. Table 10 summarises these categories and provides illustrative examples of how public actors across Europe implement them.

Table 10. Types of interventions implemented by public actors to support sustainable climate adaptation

Group	Type	Examples
Financial framework & investment	Readjusting financial incentive structure (taxes, subsidies)	French Water Agencies support farmers through Payments for Environmental Services schemes rewarding sustainable practice changes.
	Investments in infrastructure or landscaping	The construction of the Alqueva Dam (Portugal) allowed for large swathes of additional irrigated land and transformed regional agriculture.
	Providing insurance	Austria's drought insurance scheme combines indemnity-based and weather-index products under a subsidised public-private model to manage agricultural risks.
	Investment support	Slovakia implemented a national programme funding village-level nature-based solutions with simple applications and grants, implemented in over 500 communities.
Education, information & advice	Making available advisory support / technical assistance	In Austria, the Soil.Water.Protection.Advisory system (BWSB) delivers farm-based consultations and field demonstrations, enabling the adoption of soil and water conservation practices.
	Making available tools	The Dutch Climate Adaptation Platform offers free online tools supporting spatial adaptation planning.
	Facilitating mutual learning & knowledge transfer	In Rhineland-Palatinate (Germany), a two-stage knowledge system connects research and practice: consultants trained by municipal authorities advise farmers, creating a feedback loop between science and implementation.
	Promoting research, development & innovation	In Andalusia (Spain), IFAPA regional research centres develop drought-tolerant crops and water-efficient irrigation systems, sharing results directly with local farmers.
	Model & demonstration farms	Demonstration vineyards in Gironde (France) test pruning, training, and planting densities to identify climate-resilient viticulture methods.

Group	Type	Examples
	Engaging stakeholders, raising awareness	In Emilia-Romagna (Italy), participatory workshops and scenario visualisations raise stakeholder awareness of future water-use trajectories.
	Promoting education/training on CCA	The HumusReich Network (Germany) trains farmers to regenerate soils and increase humus through workshops, analyses, and the 'Humusfibel' guide, linking practices to carbon-credit trading.
	Providing information / data	The 'Regional Stakeholder Networks for Drought Adaptation' project in Germany mapped future irrigation needs and engaged water stakeholders, showing potential demand could rise up to 31% by century's end.
Risk management	Risk assessment / warning systems	In Catalonia (Spain), the Meteorological Service operates an early-warning system for droughts and heatwaves, providing farmers and authorities with actionable alerts.
	Response plans	Drought management plans set water allocation priorities and alert levels within regional river basin authorities.
Regulation & monitoring	Management of resource use	Dutch and German irrigation associations manage water withdrawal collectively to balance access and promote fairness among farmers.
	Enforcement	In Murcia (Spain), river basin authorities enforce against illegal water abstraction to protect wetlands and ensure sustainable irrigation.
Other	Facilitating stakeholder cooperation & coordination	Water management authorities in southern Germany support irrigation associations through co-funding for infrastructure, fostering collective water management for climate adaptation.

Source: stakeholder interviews, discussions, desk research.

Results from the stakeholder survey (n=100) indicate that public bodies (n=32) and research/technical institutes (n=12) across the EU have developed strategies, tools, and targeted changes in farming practices to support climate adaptation in agriculture.²² Ten public bodies and eight research or technical institutes reported formal **strategies**, implemented at national (n=9), regional (n=6), local (n=7), landscape (n=2) and EU level (n=1). Public bodies and research institutes also developed various **tools** to support farmers in making informed climate adaptation decisions. Nine public authorities and seven research institutes²³ reported creating such tools at the national (n=10), local (n=1), regional (n= 4) and landscape level (n=1).

Open-ended responses provided further insight into specific tools. For instance, France's Sustainable Agriculture Contract, which helps farmers develop tailored agroecological transition plans, the Leviers d'Acclimatel which proposes a selection of resources on CCA strategies for cattle farms. Sweden's national advisory module on agricultural water supply, guiding farmers across sectors like cereals, oilseeds, and livestock. In Cyprus, advanced irrigation systems integrate evapotranspiration estimates to optimise water use. An overview of

²² Responses from public authorities to the stakeholder survey are limited to total n=32 and are not representative of all MS. Responses include Republic of Cyprus (n=1); Czech Republic (n=1); France (n=4); Germany (n=2); Italy (n=2); Lithuania (n=3); Poland (n=12); Portugal (n=2); Romania (n=1); Spain (n=1); Sweden (n=1).

²³ Public authorities and research institutions providing evidence on the development of tools and strategies include representatives from France, Republic of Cyprus, Portugal, Lithuania, Greece, Germany, Hungary, Sweden, Spain, Czech Republic, Italy, Poland, Romania and the Netherlands.

the tools reported by public bodies and research institutions is outlined in Table 11.

Table 11. Summary of open-ended responses from stakeholder survey: Tools reported by public bodies and research institutions

	Public bodies	Research institutions
Tools	(i) Implementation of subsidies and investment support for the implementation of sustainable technologies. (ii) Infrastructure and training tools to support water supply. These tools include advance irrigation systems, and advisory modules to support water supply and reduce water losses. (iii) Development of tools such as the "Sustainable Agriculture Contract" which helps diagnose the farm across 4 axes of sustainability: autonomy and resilience, protection of resources, quality of life, financial situation and supporting farmers in defining their agroecological transition project in 5 years.	(i) AGIR: An informatic tool to estimate water application efficiency in irrigation systems (ii) ClimAléas diag Bovin diag: A tool to help diagnose the impact of climate change on cattle farming. . (iii) Models and maps of water management in river catchments and carp farms. (iv) Irrigation support tools such as IrriFrame, Tecrirri, SETI - dss , and Faldanet – db. (v) Digital learning tools such as the educational and training project 'SErious Game in AgroEcology (SEGAE)

Q8a Stakeholders survey. Which tool(s) did you develop? [open text]. Coded. Base n= 16 (n= 9 public bodies and n= 7 research institutions) of 100

Moreover, findings from the case studies offered key examples such as Austria's *ehyd* and *naturgefahren.at* platforms, which provide real-time hydrological data and early-warning systems for drought and flood risks. France uses tools like the *SAFRAN-SURFEX* model and regional water observatories to track water availability. Italy's *IRRIFRAME* system offers digital irrigation advice, while Spain's *SIAR-CAT* and *DESEMON* provide localized climate projections and irrigation guidance. In Poland, the Institute of Meteorology and Water Management offer drought monitoring tools for both national and regional decision-making.

2.1.3 SQ 1.3 – What strategies and tools as well as changes in farming practices aim to increase water resilience in particular and what strategies, tools as well as changes in farming practices address other CC induced needs?

Many changes in practices, tools and strategies have been developed by farmers, scientists, private actors and public authorities to respond to water-related challenges associated with CC, including water scarcity/droughts, soil erosion and floods / heavy rainfall. Crucially, not all these actions improve water resilience. Some can be unsuitable and even lead to maladaptive consequences. The factors of agricultural changes in practice, tools and strategies that lead to maladaptive outcomes is discussed in Section 2.2. This section explains the changes in practice relevant to the EU which have been

developed to *respond* to water-related CC impacts or threats, including those often deemed as maladaptive. It is not always clear the extent to which all these changes in practice have been *implemented*, but some data on the extent of uptake has been included throughout this section and in the inventory. Section 2.5 builds on this section, evaluating which of the practices outlined in Section 2.1 can enhance water resilience, and also covering factors associated with effective governance and implementation.

A total of 17 practices related to water management were estimated to be widely practiced in at least one MS. However, at least one of these does not necessarily contribute to increasing water resilience, namely, groundwater extraction. There were also some practices which were estimated to be widely implemented in one country but not another. For example, seasonal calving for fodder management, a practice which aims to mitigate the impacts of drought by aligning calving with periods of highest fodder availability, was estimated to be widely practiced in Ireland but only practiced by a minority in France.

The EU's Water Resilience Strategy (European Union, 2025) sets out objectives for working towards water resilience. It prioritises demand reduction and efficiency improvements and highlights the power of green infrastructure to retain water on land, thereby improving water resilience. As per the Water Efficiency First guiding principles, the water-related changes in practice in the inventory have been split into those which aim to reduce water demand, increase efficiency, reuse water and extend water supply.

Reducing water demand

Water demand can be reduced by supporting rainfed agricultural systems (estimated to be widely practiced in France in the expert consultation), through measures which reduce the requirements for irrigation or landscape morphology and soil management measures which improve retention of water within the farmed landscape.

Switching to crops which have lower water requirements can reduce the water consumption of a farm. This can be done through switching to more drought resistant varieties of the same crop or switching crop types altogether (AWA AgriAdapt, 2020; European Commission, 2016; De Leo et al 2024). Findings from the expert consultation indicated that most of these types of practices were implemented by only a marginal proportion of farmers, noting that some of these practices were more common in some countries. For example, cultivation of late ripening varieties of grape in vineyards was estimated to be widely practiced in France. As mentioned in Section 2.1.1, desynchronisation and diversification practices also address water-related climate risks by reducing the risk that all plants will be hit by extreme events at critical phenological stages by specific impacts that they are equally susceptible to (AWA AgriAdapt, 2020; De Leo et al 2024). Some of these practices are more common, such as the

practice of timing phenological development in horticulture and perennial crops to avoid summer heat and droughts which was estimated to be widely practiced in Ireland by two experts.

Soil management plays a crucial role in regulating both the retention and drainage of water. Many of the recorded practices aim to increase the soil's capacity to hold water, thereby reducing the vulnerability of crops during dry periods (AWA AgriAdapt, 2020; De Leo et al 2024; European Commission, 2016; JRC 2025). These practices can also enhance drainage during periods of heavy rainfall by improving soil structure and porosity, helping to prevent waterlogging and reduce surface runoff (ibid). A key lever in this context is the management (retaining or adding) of soil organic matter which directly influences the soil's ability to absorb and retain water. 78 out of the 94 crop farming respondents to the farmers survey who have implemented changes in practice to adapt to CC stated that they have sought to improve the condition and health of the soil, a much higher proportion than any of the other options.

Although already covered in Section 2.1.1, it must be highlighted that practices such as cover cropping, conservation tillage and control of the movement of farm machinery alongside other measures which improve/maintain soil structure and fertility are key for improving water resilience on farm (AWA AgriAdapt, 2020; Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, 2021). Structural natural landscape features such as windbreaks, hedgerows, and tree lines also play a role in increasing resilience to extreme weather events by reducing wind speed, protecting soil surfaces, and limiting sediment displacement, all while retaining green water reserves on farm (De Leo et al 2024).

Increasing efficiency

Many techniques aim to improve water use efficiency by optimising irrigation location (e.g. under-canopy, on- or underground) or timing (e.g. night-time irrigation, irrigation only during sensitive crop stages) according to crop needs and by minimising evaporation (De Leo et al 2024; European Commission, 2016). Efficiency improvements also include sub-optimal or deficit irrigation strategies, where crops are irrigated below their full water requirements, and approaches such as partial root zone drying, which alternate wet and dry areas to stimulate deeper root growth and internal water efficiency (AWA AgriAdapt, 2020; European Commission, 2005). Farmers may also adopt intermittent flooding cycles such as alternate wetting and drying in paddy fields (FAO, 2013). Other targeted practices include the Cocoon system for young trees, which enables water conservation and root development in arid conditions (De

Leo et al 2024).²⁴ Results from the expert consultation indicated that night-time irrigation and adaptation of irrigation based on wind conditions to minimise water loss were widely practiced in France.

Monitoring tools like water meters and tensiometers, as well as software for water budgeting or piloting irrigation, can be used to reduce unnecessary irrigation (AWA AgriAdapt, 2020). Pre-season irrigation planning and annual servicing of irrigation infrastructure can safeguard reliable supply in critical periods and reduce loss (European Commission, 2016). Technologies such as drip and underground micro-irrigation, soaker hoses, aerated irrigation, and precision irrigation, sometimes supported by thermal sensors or drones, can help deliver water directly where it is needed while minimising loss (De Leo et al 2024; European Commission, 2016; JRC, 2025; Morel and Cartau, 2023). Optimisation of water use through piloting was only estimated to be implemented by a minority of farmers in Germany, and similarly, only 40 out of the 118 respondents to the farmers survey who have implemented measures to adapt to CC reported that they have sought better information about weather, moisture, temperature, soil or animal conditions at the farm.

To reduce water loss from storage, various measures can be implemented. For instance, irrigation ponds can be covered with concrete lids or more commonly with polyfibre or polyethylene shade cloths (Velasco-Muñoz et al., 2022). These coverings significantly reduce evaporation and are also valued for improving water quality, reducing pond maintenance needs, and contributing to occupational safety. Farmers can install such covers themselves at relatively low cost. Conveying irrigation water through closed pipes rather than open channels is another effective measure to limit evaporation (Serra Wittling et al., 2020). Nevertheless, in the expert elicitation, the covering of irrigation ponds was only estimated to be implemented by a marginal proportion of farmers in Germany.

Reusing water

Water storage practices including various types of tanks, basins, or reservoirs allow farms to store water from diverse sources, including runoff, stormwater, roof drainage, and wells (Climate ADAPT, 2023; Pedretti et al., 2023; AWA AgriAdapt, 2020; De Leo et al 2024). Rainwater can be collected from rooftops into small tanks for individual farms or shared among rural communities, often combined with filtering and storage systems (AWA AgriAdapt, 2020). Fog and dew harvesting for agriculture remain experimental in Europe, with localized use

²⁴ Although the Cocoon system is primarily applied in reforestation, the CAMBIA library also highlights it as a practice to support tree planting in perennial crop production. Evidence from Catalonia further indicates its use in establishing perennial crops (including within agroforestry systems), including olive, walnut, cherry, and fig trees, see CREAF (2020), 'The Cocoon system improves success rates when reforesting degraded land', available at <https://www.creaf.cat/en/articles/cocoon-system-improves-success-rates-when-reforesting-degraded-land>.

in coastal or elevated arid zones (Hadba et al., 2020; Estrela et al., 2019).²⁵ Surface water can also be captured via small reservoirs, which may serve both farm-level and inter-farm needs (De Leo et al 2024). Nevertheless, if too much water is captured or diverted, this can cause aridification elsewhere in the catchment. When designed with nature-based solutions which allow water to infiltrate the ground, these reservoirs can also provide environmental co-benefits. They may also support multipurpose uses, such as the installation of solar panels.

Wastewater reuse (De Leo et al., 2024), encouraged under EU Regulation 2020/741, is a growing strategy for irrigation, especially in regions where water scarcity is persistent, such as parts of the Mediterranean. Micro-catchment systems and runoff harvesting using semi-circular bunds or small water ponds represent low-tech, decentralized options to trap rainwater for later infiltration or use, helping farmers store water within the root zone or in landscape-integrated reservoirs (Pedretti et al., 2023; Srivastava, 2013, AWA AgriAdapt, 2020).

A range of interventions aim to reshape farm or landscape morphology to manage water flow more effectively, capturing run-off and slowly replenishing groundwater. These include design strategies such as contour farming, terracing, ridge-and-furrow systems, and keyline design, which are particularly relevant on sloped or uneven terrain (European Commission, 2015; De Leo 2024; Shmidt et al., 2023; Catsadorakis et al., 2021). By redirecting or slowing runoff, these measures enhance water infiltration, reduce erosion, and in some cases support on-farm water harvesting. All practices relating to water reuse were either not assessed by experts in regard to level of implementation or estimated to only be implemented by a marginal proportion of farmers.

Extending water supply

The inventory has recorded farm-level practices to extend or diversify water supply to respond to more frequent or prolonged droughts and overall reduced rainfall. These include authorised abstraction of freshwater (from lakes, rivers or aquifers), authorised harvesting of rainwater (e.g. from roofs), and fog and dew harvesting (Xanke and Liesch, 2022; AgriAdapt, 2020; Hadba et al., 2020; Estrela et al., 2019). Seawater desalination and wastewater reuse is also a possibility, but more likely to be implemented by actors above the farm-level such as public authorities (De Leo et al., 2024; Aznar-Sánchez et al., 2017).

Practices aimed at increasing water supply are controversial, as the abstracted water will create water scarcity for use elsewhere and risk to increase water dependency without real adaptation, in reality decreasing the resilience. The

²⁵ See, for instance, <https://www.nieblagua.com/proyectos/finca-solebromino>. See further Estrela, M. et al, Spatio-temporal variability of fog-water collection in the eastern Iberian Peninsula: 2003–2012, *Atmospheric Research*, Vol. 226, pp. 87–101, <https://doi.org/10.1016/j.atmosres.2019.04.016>.

conditions for abstracting water are key to determining whether the practice is adaptive or maladaptive (see discussion in Section 2.2. below). Groundwater abstraction, for example, may offer a short-term buffer during dry periods, but risks long-term depletion if replenishment through rains and natural flows are not in balance with the abstraction rates. Nevertheless, the expert consultation revealed that groundwater abstraction for irrigation is widely practiced in Germany.

Desalination, while energy- and cost-intensive, and contributing adverse impacts on the environment and increasing CC, is increasingly considered in coastal areas for high-value crops, particularly using reverse osmosis technology adapted for agricultural use.

2.2 SQ2: Which factors and how to determine the suitability of CCA strategies, tools and changes in farming practices?

To assess the suitability of CCA changes in practice, the maladaptive risk posed needs to be understood, which includes the following factors: risk of vulnerability rebound, risk of shifting vulnerability, risk of negative externalities, risk of lock-in and the comparison of the relative risk to other available options including inaction. Considerations whether the enabling conditions are in place to allow the changes in practice to be effectively implemented need to be considered. To assess the suitability of CCA strategies comprising of a collection of different changes in practice, the depth of transformation of each constituent change needs to be assessed, and the selection should include a majority of transformative changes, alongside fewer incremental and even fewer reactive changes. The exact selection of changes depends on the local context. To assess the suitability of CCA tools, it must be considered if they are accessible and the extent to which these tools enable the user to successfully implement effective CCA changes in practice and avoid maladaptive outcomes.

2.2.1 SQ2.1: What are the main factors determining the suitability of CCA strategies, tools and changes in farming practices?

Maladaptation risk

The question of 'suitability' of climate adaptation is at first about the distinction between 'effective adaptation' and 'maladaptation'. No maladaptive practice or strategy could be considered suitable as a means of addressing CC vulnerability. In line with the latest literature, we understand effective adaptation as 'adaptation that moderates harm or exploits beneficial opportunities, that is,

that reduces climate risk by either reducing vulnerability or exposure to CC related impact', and maladaptation as 'adaptation with negative consequences that increase climate vulnerability, that shift vulnerability or exposure, or that erode sustainable development²⁶, now or in the future' (Reckien et al., 2023; also Schipper, 2020, Neset et al., 2019, IPCC 2022).

Maladaptation can only be classified as such if they render people more likely to be negatively affected by CC (Higuera Roa et al., 2025). Therefore, impacts must be considered relative to other adaptation options or inaction. If the intervention, or decision for inaction, is the least socially, economically and environmentally harmful option presently identified for all stakeholders now and in the future, it cannot be classed as maladaptive (ibid.).

Higuera Roa et al. (2025) highlight how ignoring the high degree of interconnection between agricultural systems and exogenous factors such as the environment, climate and markets during the design, selection and implementation of adaptation actions can lead to maladaptive outcomes, as they can exacerbate risks in other climate-sensitive systems. The pathway towards climate and water resilience exists within a dynamic and complex environment where the scale and pace of future consequences of CC are unknown and additional non-climate factors influence the success of adaptation (Schipper, 2020). Therefore, adaptive actions must constantly be reviewed to assess whether they are on track towards improving resilience or veering towards the generation of adverse consequences (Higuera Roa et al., 2025; IPCC, 2022).

One of the non-climate factors to consider is the feasibility of selling different or new products as a result of implementing a change in practice (such as switching to more drought-resistant crops). These crops must be marketable, have sufficient demand and there must be the appropriate capabilities and capacity within the whole supply chain to bring the produce to a consumer-ready state. A full discussion on how to transform the broader food value chain to enable it to get to this state is out of the scope of this project, but the economic sustainability of adaptations is a key element of avoiding the erosion of sustainable development, one of the symptoms of maladaptation.

The factors affecting maladaptation risk are summarised in Table 12, alongside the adaptation intervention characteristics that represent a risk of maladaptation in relation to each factor, and those that signify a likelihood of avoiding that risk of maladaptation. An example of maladaptation in relation to each factor is also provided to illustrate how maladaptation risks can materialise with respect to each factor.

²⁶ As defined by the Brundtland Report (World Commission on Environment and Development, 1987)

Table 12. Factors to be considered to assess maladaptation risks

Factor	Adaptation characteristics representing maladaptation risk	Example of maladaptation
Risk of vulnerability rebound	There is a risk of the intervention making the farmer more, rather than less vulnerable, to the same climate hazard or another	The Austria case study highlighted how switching from traditional grass species to more heat tolerant and less water-hungry maize for fodder production in dry years can significantly increase soil erosion risk, ultimately increasing risk to CC.
Risk of shifting vulnerability	There is a risk of the intervention causing an increase in CC vulnerability for other farms, people, economic sectors, or ecosystems.	Local groundwater extraction by one farmer to increase irrigation in response to drought lowers the water table for the entire aquifer, increasing risk of water shortages for surrounding farmers (Minea et al., 2020).
Risk of negative externalities	There is a risk of the intervention causing other negative externalities which erode sustainable development	The Italy case study highlighted how plastic mulching is sometimes introduced to reduce evaporation, control weeds and mitigate soil warming, but this leads to high levels of plastic pollution.
Risk of lock-in	Implementation of the adaptation causes a lock-in to a specific pathway which limits the possibility of implementing different adaptation options in the future if unintended consequences occur. This includes if adaptation effects are difficult to monitor.	Implementation of artificial agricultural drainage to reduce risk of waterlogging as an adaptation to increased heavy rainfall under CC is often expensive and difficult to remove once installed. If rainfall increases unexpectedly in the future, flood risk could also be exacerbated by the drainage implemented, depending on the local conditions (Ballard et al., 2011). If the farmer is unable to easily remove the drainage system and adopt different practices, this presents an enhanced risk of further deterioration.
Comparison to other available options	Other adaptation pathways including inaction represent options of lesser harm compared to the chosen adaptation pathway	If weed intensity is not too high and the soil fertility is low, it is usually more suitable to use organic materials for mulching over plastic (Ranjan et al., 2017). It would therefore be maladaptive to introduce plastic mulching when organic mulching has fewer negative externalities.

The impact of the lock-in risk factor encompasses aspects of vulnerability rebound, shifting vulnerability and negative externalities, since if it is present, it will exacerbate the extent of the impact of any of the other risks which are relevant to the maladaptive practice. The inclusion of lock-in as a separate risk factor is due to an acknowledgement that any change in farming practice exists within a dynamic environment of many interacting factors, meaning that a maladaptive risk that was not initially apparent can materialise at a point in time after the change in practice has been implemented. If it is difficult to amend or revoke that change in practice, the maladaptive effect will be exacerbated.

However, lock-in risk is extremely context dependent, even in the example outlined in Table 12. The lock-in risk of installing a drainage system depends amongst other things, on the budget that the farmer is operating with and the type of drainage implemented. Furthermore, the actual risk of maladaptation of drainage is dependent on landscape factors and again, on the type of drainage implemented. Innovative methods of agricultural drainage such as level-controlled drainage have been developed which pose less maladaptive potential. This method employs technology which allows farmers to regulate the

water level to dynamically suit the needs of the crop (EU CAP Network, 2019). This method both retains soil moisture to the degree required, reducing the large fluctuations often found in conventional drainage, and reduces erosion, resulting in reduced rebound vulnerability risk compared with conventional drainage systems (Kalibatiené et al., 2025). It also poses less risk of peat oxidation than conventional drainage if implemented on organic soils, minimising soil subsidence, contributing to long-term carbon retention. Nevertheless, inadequate management of controlled drainage can lead to adverse consequences such as water quality issues, waterlogging, root oxygen stress, or increased susceptibility to soil-borne diseases. Furthermore, maintaining higher water levels may reduce field trafficability and delay agricultural operations if not managed carefully. Level controlled drainage must be coordinated at the catchment level, otherwise it can lead to increased downstream flooding risk if all farmers release water from their system before an anticipated storm. An interview with a water management expert highlighted that drainage of any type is used when the fields are not suitable for the type of land use. This raises the question of whether those fields should be adapted or if the land use should instead be optimised.

Depth of adaptation

While the definitions above set effective adaptation as positive and maladaptation as negative, their application to qualify farming practices or strategies can be challenging. Indeed, the academic literature suggests that for adaptation actions to set society on a transformative pathway towards climate resilience, the root causes of vulnerability to CC must be addressed, which are constituted by a multitude of systemic inequalities causing certain groups to be more heavily impacted than others by the same climate hazards (Schipper, 2020). Otherwise, adaptations can only address the symptoms rather than the cause of vulnerability, and they run the risk of increasing vulnerability and becoming maladaptations.

It is therefore appropriate to consider a continuum between effective adaptation and maladaptation, as discussed in Schipper (2020) and Reckien et al. (2023). From the centre of the continuum, the first step towards effective adaptation is where the CC impacts (but not the vulnerability to those impacts) are addressed. Once the specific vulnerability is also addressed, the intervention moves closer towards effective adaptation. At the far end of the scale is a transformation in which the adaptation goes even further to address the root causes of vulnerability. These different types of effective adaptation are commonly known respectively as reactive, incremental and transformative. As one moves towards the other side of the continuum, a maladaptive pathway emerges of increasing vulnerability and inflexibility as the subject becomes locked into a certain pathway with fewer alternative adaptation options and increasing risk of rebound vulnerability, shifting vulnerability, and erosion of sustainable development. Naturally, the climate change exposure, vulnerability

and root causes of vulnerability vary geographically and throughout society, inferring differential adaptation intervention outcomes depending on context (Higuera Roa et al., 2025).

The distinction between reactive, incremental and transformative adaptations is sometimes ambiguous and the terms are not always named consistently throughout the literature. However, the literature tends to categorise depth of adaptation as follows (Kelder et al., 2025; Reckien et al., 2023; Shipper, 2020):

- **Reactive adaptations:** Practices aimed at addressing the consequences of vulnerability to CC have short-term effectiveness. These are measures to increase readiness and improve response processes in the event of climate-related harm to the system. However, they do not seek to overhaul the system. One example of this is insurance.
- **Incremental adaptations:** Practices aimed at reducing vulnerability to CC have medium-term effectiveness. These targeted adjustments reduce vulnerability to CC, but do not fundamentally change the system. One example of this is switching to varieties more suited to the changing climate.
- **Transformative adaptations:** Practices aimed at addressing the root causes of vulnerability to climate change and demonstrating long-term effectiveness. These are deep, systemic or structural interventions that reshape the system fundamentally, thereby improving its resilience to CC. One example of this is switching to organic farming.

‘The right mix of measures’

The long-term objective of adaptation is resilience to future climate impacts. Resilience is best understood as the ability to bounce back from shocks. It is therefore an outcome measure. Effective adaptations taken individually would not in themselves contribute much to resilience, especially if they are reactive. Rather, the literature (Kelder et al. 2015) shows how a strategic selection of several adaptation interventions implemented and maintained successfully under enabling governance conditions can grant the wider socio-ecological system the ability to bounce back from climate hazards. This implies, in decreasing order of importance, a combination of transformative, incremental, and reactive adaptation practices. Such a diverse portfolio of practices can build diversity, flexibility, redundancy, buffers, and new resources to withstand shocks and bounce back. Consequently, although transformative adaptation can be understood as the most effective interventions for adapting to CC, reactive and incremental adaptations also have their place in the broader resilience building strategy. For example, in the agricultural context, introduction of weather alert systems mostly enables only reactive responses and as such would not contribute much to building resilience (although it can also contribute to increased awareness of weather challenges to an extent). Nevertheless, there is little doubt among climate adaptation experts working on agriculture that

weather alert systems is needed and useful as part of the right ‘mix of measures’.

Enabling conditions

Several **enabling conditions** support the realisation of CC resilience. Not only do these factors help to avoid maladaptive outcomes, but they also enhance the effectiveness of adaptive interventions. They are summarised in the 6th Assessment Report of the IPCC (IPCC, 2022), and include:

- Political commitment and follow-through to improve confidence and ensure delayed benefits are realised. This is reinforced by institutional frameworks, policies and instruments with clear goals and priorities which mainstream action and allow for efficient coordination.
- Enhanced knowledge on impacts and solutions to allow for identification of choices which maximise benefits and minimise risk.
- Mobilisation of and access to adequate financial resources to reduce barriers to entry.
- Monitoring and evaluation to ensure quick response to changing conditions or emerging risks and opportunities.
- Inclusive governance processes which prioritise equity and justice, enabling interventions to address differing levels and forms of vulnerability.

Costs of implementation and opportunity costs, technical skills and knowledge requirements, and conditionalities related to the effectiveness of adaptation should all be considered when choosing which adaptations to support or implement. Changes in practices which are low cost to the farmer, effective in a wide range of contexts and require little additional skill to effectively implement are often supported due to being seen as no-regret options. However, this must be balanced with the potential for transformation towards more resilient systems and society. Many nature-based solutions such as wetland restoration can be expensive for individuals both in terms of capital and opportunity costs yet still yield significant public benefits in terms of adaptation to CC which can outweigh those costs. Additionally, lack of knowledge can be seen as a significant barrier to the proliferation of some practices such as intercropping (Chevalier et al., 2024), but this does not disqualify the sizeable potential for the practice to address challenges faced by agriculture, including reducing vulnerability to CC.

Enabling conditions are particularly important with respect to the suitability of broader strategies designed to make agriculture more resilient to CC. To ensure suitability to the local hydrological context, strategies to address water-related CC impacts should be coordinated at catchment level, allowing integrated management of water resources and related risks. To address the challenges associated with the context dependence of maladaptation risk, it is critical that

local stakeholders are fully engaged with decision-making around adaptation intended to support them (Schipper and Mukherji, 2024). Participation must be encouraged throughout selection, design, implementation and evaluation of interventions to ensure equitable outcomes throughout the catchment. Local participation in adaptation decision-making allows for more accurate consideration of the vulnerability context of the entire catchment and its inhabitants.

Enhanced knowledge of solutions, access to (and promoted use of) reliable and accurate meteorological data and climate projections, and availability of training are vital aspects of effective adaptation, as imperfect knowledge and poor decisions can often cause potentially effective adaptations to become maladaptive (Schipper, 2020). The section below highlights the key factors affecting the suitability of tools which help farmers adapt to CC.

Tools

This section has discussed the suitability of changes in farming practices principally. Tools, which allow stakeholders to make operational decisions on CCA cannot necessarily be analysed in the same way. They are not adaptation actions in themselves. Rather, they are available to farmers and other stakeholders to enable them to make informed adaptation decisions. The suitability of tools is therefore more dependent on the accessibility of the tool, the support for its use, and the utility of the tool in helping farmers implement good practices and avoid maladaptation. If a tool improves all farmers' capabilities to implement good practices effectively, it is suitable. If it leads to poor decision making or encourages the uptake of maladaptive practices, it cannot be deemed suitable.

2.2.2 SQ 2.2: To what extent do these factors determine the suitability (or the lack thereof) of CCA strategies, tools and changes in farming practices?

The concepts discussed in Section 2.2.1 suggest that the suitability of any adaptation intervention is broader than a binary judgement of maladaptation risk considered in isolation. As such, one may consider four successive and complementary steps to determine the suitability of an adaptation strategy in the agricultural context:

1. **Maladaptation risk:** What are the risks of maladaptation and potential for effective adaptation for each change in farming practice included in the strategy, considering the local context?
2. **Enabling conditions:** Is it feasible to equitably implement them effectively in the current conditions?

3. **Depth of adaptation:** Is each change in practice or strategy an example of a reactive, incremental or transformative adaptation?
4. **'The right mix':** What would be the suitable combination of these incremental, reactive and transformative adaptation practices?

Academics (Higuera Roa et al., 2025), EU Member States such as Austria and Germany (EPA Network, 2025) and the European Commission (European Union, 2023) have all developed guidance on how to design adaptation plans which mitigate the risk of maladaptation. One Horizon 2020-funded project produced a checklist to assess maladaptation risk during the development of adaptation plans or strategies (REGILIENCE, 2023). All these examples highlight the importance of considering maladaptation risk ex-ante. Although they do not all present the same list of criteria to consider, there are some similarities. They all consider the risk of vulnerability rebound and shifting vulnerability risk, the risk of deleterious impacts on sustainable development (some disaggregate this further to specify impacts on social inequality, CC mitigation, economic sustainability etc.), detrimental lock-in risk and the importance of continuous monitoring, and assurance that other options have been considered. This demonstrates broad alignment with the conceptualisation of maladaptation presented in this study. At least a portion of the necessary enabling conditions outlined above are considered in each of the resources, with some focusing on creating a synergistic policy environment or participatory governance structures, while others focus on ensuring processes are set up for effective monitoring of adaptation impact. Depth of transformation and a focus on combining adaptation practices depending in part on these characteristics is mentioned to some extent in some resources such as Higuera Roa et al. (2025), REGILIENCE (2023) and European Union (2023).

To guide ex-ante assessment of adaptation options in context, the study team conducted a preliminary assessment of the general maladaptive potential of the changes in agricultural practice presented in the inventory based on the conceptualisation of maladaptation presented in Section 2.2.1. Each practice was assigned one of the following judgements based on information collected during the meta-analysis which informed the inventory:

- Likely to avoid maladaptive outcomes: No evidence has been identified to suggest that the practice can produce maladaptive outcomes.
- Ambiguous / context-dependent: Factors have been identified that suggest the practice could produce maladaptive outcomes, but only in specific contexts.
- Risk of maladaptation: Factors have been identified that suggest the practice can a) increase climate vulnerability, b) shift vulnerability or exposure, or c) erode sustainable development, now or in the future

It should be stressed that this assessment is generalised and based only on the information collected during the literature review and expert consultation. To reiterate, 'every adaptation option shows some potential for both adaptation and

maladaptation' (Reckien et al., 2023). Due to the general nature of the assessment, the factor of 'Comparison to other available options' has not been addressed as this depends on identifying options available in a specific context. Furthermore, 'Risk of lock-in' has also been excluded since, as explained in Section 2.2.1, in most cases this is too context-dependent to qualify in a generalised sense.

The study team also used the information available in the inventory to assess the depth of adaptation of each practice based on the nomenclature outlined in Section 2.2.1. Both the judgements for maladaptation risk and depth of adaptation were validated for each practice in the inventory by at least one expert based in an EU MS during the expert consultation exercise (see Section 1.3.2 for the full method). Where the expert disagreed with the study team's verdict, the practice was reassessed based on their explanation.

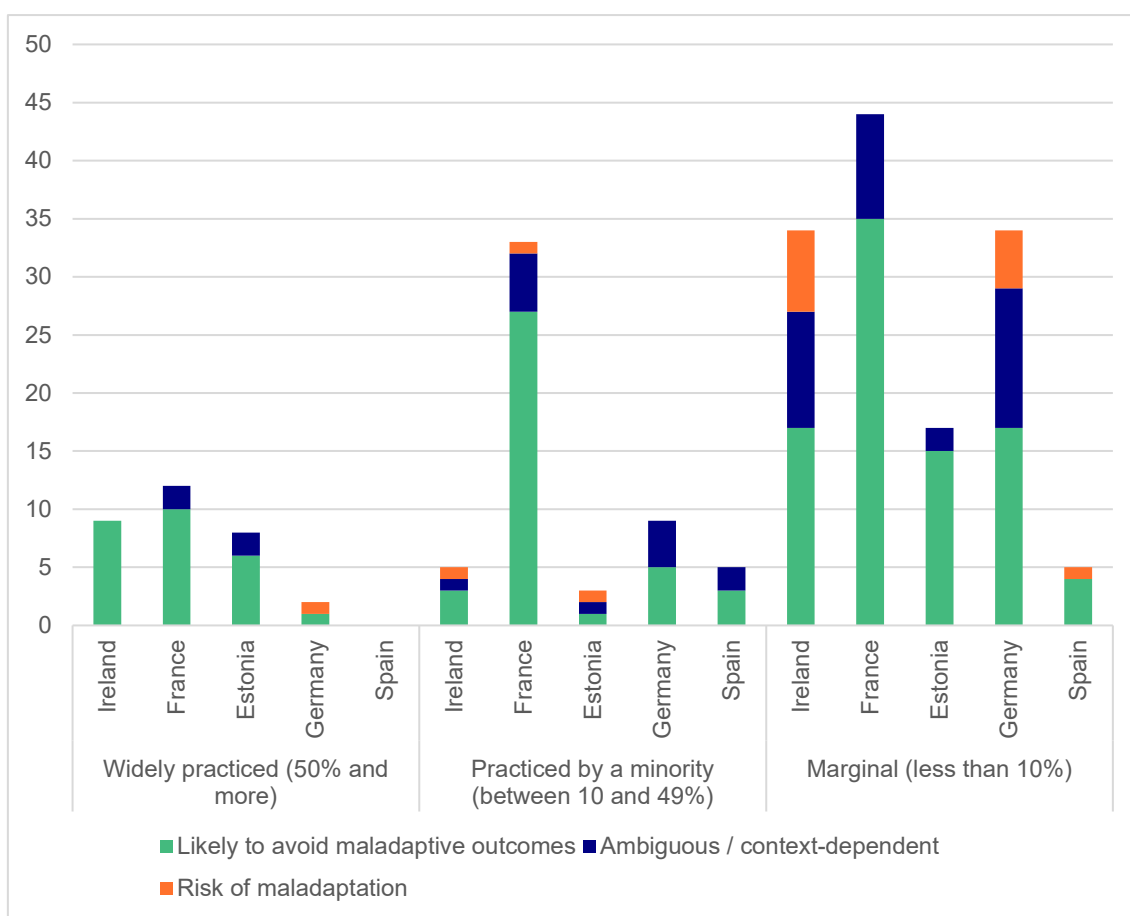
The finalised judgements for maladaptation risk and depth of transformation are presented in the inventory for each change in farming practice. The majority of practices identified were labelled as incremental, and the vast majority were found to likely avoid maladaptive outcomes. However, 56 practices could present a risk of maladaptation depending on the context, and specific maladaptive risks were identified for 24 practices, regardless of the context (Table 13). It should be stressed that a risk of maladaptation does not mandate it as an outcome, as the risk might be mitigated if implemented to carefully avoid maladaptive outcomes. Nevertheless, if practices without a risk of maladaptation and with similar desired impacts are available, these should be prioritised, as per the 'comparison to other available options' factor. The results also highlight that although transformative practices tend to avoid maladaptive consequences, there are some transformative practices that present a risk of maladaptation. Examples of this include no-till farming, which presents a risk of maladaptation due to the common increased application of herbicides in this farming practice. Another example is investment in desalination to provide water for irrigation, which can lead to energy dependency, as will be discussed in Section 2.5

Table 13. Changes in farming practice identified in the inventory judged in terms of their maladaptive potential (ambiguous/context dependent or risk of maladaptation) and their depth of adaptation (reactive, incremental or transformative)

	Reactive	Incremental	Transformative
Ambiguous / context-dependent	Adapt date of sowing & variety precocity; Anti-freeze over-tree irrigation; Anti-freeze under-tree irrigation; Anti-insect nets; Filter nets for shading; Foil roofs; Hail protection nets; Increase machine capacity; Increasing the use of supplementary feeding; Install backup power generator; Irrigation scheduling; Laser levelling in flood irrigation; Multifunctional nets: anti-hail, anti-cracking, anti-insect; Optimisation of the time of irrigation (during the day); Over-tree cooling irrigation; Quality watering; Rain protection and anti-cracking cover; Sprinklers in stables	Application of fertilizers in increments; Biochar; Covering irrigation ponds; Drip irrigation; East-west row orientation in trellised orchard/vineyards systems.; Fertirrigation; Improvement of soil drainage; Irrigation of young plants; Liquid manure management; Manure; Night-time irrigation; Optimised irrigation period; Plastic mulching; Precision irrigation; Regular application of organic fertilizers; Self-driving machines; Slurry with eco-sustainable practices (injected into the ground); Soaker hoses; Subsoiling if a hard pan is present; Surge irrigation with furrows; Under-canopy micro spraying; Underground micro-irrigation; Using center pivot machines with suitable sprinklers	Cover crops for fodder; Diversify production; Focus on quality production instead of quantity; Grain production autonomy; Greenhouses; Introduction of foreign varieties adapted to local climate conditions; Micro-catchment water harvesting; Modifying the area of cultivation; Move farm to cooler areas; No irrigation; Precision farming; Rainwater collection basins and ponds; Relay cropping; Sub-irrigation via drainage system; Wastewater re-use
Risk of maladaptation	Active ventilation in buildings; Anti-freeze fans; Anti-freeze products to apply to the plants; Anti-freeze spark plugs and burners; Anti-freeze-fan rotary system from the ground; Anti-frost candles; Cooling of the grape harvest (solid co2); Damage-related insurance; Electric heating systems; Index-related insurance; Insurance against production risks; Mobile gas turbines; Mutual funds; Other anti-frost air remixing systems; Preparedness for earlier application of crop protection; Roof sprinkling; Sprinkler irrigation; Weather derivatives	Groundwater abstraction; Reuse of wood chips in fields	Desalination; No-till farming / direct seeding; Small reservoirs fed by surface water courses; Vertical farming

When maladaptation risk is cross-referenced with the assessment of extent of implementation of changes in farming practice, the results show that at least 1 practice which have an identified risk of maladaptation are estimated to be widely practiced in at least one country (Figure 5)²⁷. Namely, groundwater abstraction in Germany. This is judged as having a maladaptive risk due to increased drought risk in other parts of the catchment, and its potential to damage aquatic ecosystems. However, as mentioned in Section 2.1.1, not all practices received an estimation of the level of implementation.

Figure 5. How the changes in farming practice identified in the inventory were judged in terms of their maladaptive potential and extent of implementation, split by the country that the experts which provided the estimation of extent of implementation were referring to in their estimation



²⁷ Note that the allocation of which practices each expert should consult on was not based on the most common practices in the country that the expert was based in, but they were only asked to provide an estimation of scale of implementation for the country that they were based in.

Furthermore, contrary to Section 2.2.1 which recommends focusing on transformative changes in practice, most practices identified through the expert elicitation in their respective countries were incremental rather than transformative. Table 14 provides an overview of incremental practices widely adopted across France, Ireland, Germany and Estonia according to the validation conducted by the experts in each country.

Table 14. List of incremental practices widely adopted in France, Ireland, Germany and Estonia according to the validation conducted by the experts in each country

MS	List of incremental practices widely adopted in each MS
France	Cultivation of late ripening varieties Application of fertilizers in increments Driving on the field only in dry conditions Optimal nutrient supply Optimized hygiene Fodder stocks and portioning Adapted silage measures Crops diversification at farm level (3-5 crops) Fodder stocks and portioning Legumes in grassland Night-time irrigation
Ireland	Timing of grassland management Fodder stocks and portioning Increasing storage capacity Covering of the driving lanes Fodder stocks and portioning Increasing storage capacity Legumes in grassland Promote semi-natural spaces Timing phenological development to avoid summer heat and droughts
Germany	Tyre pressure regulation systems as a contribution to soil protection Groundwater abstraction
Estonia	Dynamic grazing Natural shelter in fields Sufficient drinking troughs Upgrade biosecurity measures Adapting to fodder shortages

2.2.3 SQ2.3: What are examples of good practices and cases of maladaptation?

This section explores several examples of effective adaptation identified through the maladaptation risk assessment, while incorporating insights from the case studies, interviews, focus groups and broader literature review.

The maintenance or restoration of natural field or farm boundaries is an adaptive practice which aims to slow down the movement of water from the soil to bodies of water and reduce erosion caused by water and wind (De Leo et al., 2024). Furthermore, the planting of hedges provides shelter and fodder for grazing livestock. Although there are costs associated with this intervention, and a medium level of technical knowledge required to effectively implement it, there

are few identified negative unintended outcomes of implementation. The measure can also bring significant benefits for biodiversity, water quality, and CC mitigation. It can also be deployed in all types of outdoor cropping or grazing systems and there is no evidence to suggest it leads to lock-in on a potentially unsustainable pathway as long as the right hedge species are used. There is a risk that hedgerows harbour both rodents which prey on the eggs of nestling birds during the breeding season, and granivorous birds which could damage grain crops, but this risk can be mitigated through attentive management, reducing hedge height and planting isolated trees (Reid and Montgomery, 2024). Land managers have planted hedgerows and in-field trees in the case study dairy farm in Pays de la Loire, driven by a motivation to improve animal wellbeing and improve self-sufficiency through use of the renewable wood provided by the natural elements. Results from one experimental farm have shown an increased growth rate in heifers potentially due to the increased provision of shade. Furthermore, heavy rainfall events have demonstrated the usefulness of hedgerows in reducing damage from excessive water.

Crop rotations entail a temporal diversification of land use which increases resilience to pests and diseases, encourages organic matter growth in soil which in turn increases soil water retention capacity, allows for deep rooting and shallow rooting to be sequenced to improve infiltration and allows farmers to diversify income sources (EIP-AGRI, 2016). This represents a transformative adaptation if the initial practice is monocropping, due to its restructuring of the temporal dynamics of cropping systems, reducing input dependency due to improved soil fertility, and enhancing long-term ecological and economic resilience, addressing climate hazards such as drought and water scarcity in particular. Although some level of technical expertise is required to create an effective crop rotation plan, there are multiple additional benefits, including increased carbon sequestration, and there are few identified negative unintended outcomes of implementation ensuring the rotation is well-planned (European Commission, 2024). It can be deployed in arable, vegetable, and mixed farming systems and there is no evidence to suggest it presents any lock-in risk. The practice is inexpensive to implement, but some rotations include growing minor crops that initially produce difficult-to-market products (EIP-AGRI, 2016). Notwithstanding, studies have shown that profitability is not a barrier to uptake of the practice (Brannan et al., 2023).

Adapting the calving period of dairy cows depending on the fodder availability is a transformational adaptation, as it represents a strategic shift in the integration of animal biology and agroecosystem dynamics. The choice on when exactly to move calving to depends on local conditions, but if the summer months are too hot and dry, grass growth can be constrained, reducing fodder availability. In such cases it can be suitable to move calving from spring to autumn, so that sufficient grass is available for cows to produce milk after calving. Cattle can also graze for an extended period in the autumn due to warmer temperatures. This measure was implemented in the case study dairy farm in Pays de la Loire,

and the results showed an increase in milk and pasture quality. Furthermore, there were reports of improved wellbeing, health, and reduced building costs as the cattle's time outside was maximised. Further, farm workers considered that the drudgery of tasks had decreased significantly due to more time spent in-field rather than in enclosed spaces.

The literature more generally points to the challenging outcomes of adaptation practices for reducing water demand, which 'have tended to be incremental, rather than transformational, and a good number have had negative outcomes for ecosystem services' (Reckien et al., 2023). The expert workshop highlighted how efficiency improvements in irrigation systems often lead to higher total water consumption unless explicitly regulated. This is due to both a hydrological paradox and a type of Jevons paradox²⁸. The hydrological paradox refers to how decreased water use does not necessarily result in decreased water consumption²⁹, since the increased efficiency means less water is being released back into the catchment. The Jevons paradox in this sense refers to the way in which increased irrigation efficiency often leads to an intensification of production or an extension of irrigated area. The Catalonia case study identified a case where a farmer upgraded from flood irrigation to drip irrigation only to observe an increase in total water use, since the drip irrigation was activated more frequently than the monthly flood irrigation. It is possible to avoid the maladaptive risks associated with irrigation efficiency improvements by reducing water allowances in proportion to the increased efficiency using the Consumption Use Index (ICU), which relates the volume of water consumed to that which is supplied, and to stop dedicating the recovered volumes of water to expand or intensify irrigated land (Aliod et al., 2025). However, these principles are difficult to promote, as they insinuate investment, energy and maintenance expenses with no increase in production capacity. Furthermore, literature has highlighted the difficulty of reliably and comprehensively enforcing water consumption caps, particularly due to issues with monitoring (Lankford and McCartney, 2024).

The rebound risk of insurance specifically relates to types of private insurance and 'solidaristic' compensation programmes. The maladaptation potential is largely due to the way that insurance and compensation disincentivise positive resilience-building adaptations, through a focus on quickly returning to business-as-usual after hazards strike, and the tendency to encourage riskier behaviour due to the safety-net that insurance provides (a phenomenon known as moral hazard) (O'Hare et al., 2016). The Poland case study explores how drought compensation constrains the motivation to adapt as it is paid out 'thoughtlessly', even if the farmer has made changes which have increased their vulnerability to CC. Research has also shown that agricultural insurance

²⁸ The Jevons paradox is a type of rebound effect whereby improvements in efficiency lead to an increase in overall resource consumption, due to decreased cost in relation to resource utility increasing demand.

²⁹ Water consumption is the water removed from the catchment through evapotranspiration.

schemes can instigate the replacement of traditional agricultural systems designed to reduce climate risk with intensive monocultures of cash crops, which entail higher climate risk levels (Müller et al., 2017; Reckien et al., 2023). There is also a discriminatory aspect of insurance, whereby some very high-risk assets are uninsurable, such as agricultural land in an area of high flood risk (O'Hare et al., 2016). This excludes the portions of society most at risk of being impacted by CC from the safety net of insurance, potentially exacerbating existing inequalities.

Further, to maintain a competitive edge private insurance companies tend not to share tools to assess risk such as models and risk maps, limiting valuable knowledge sharing (O'Hare et al., 2016). One study concluded that 'insurance fosters a cycle of maladaptation: actions (or inaction) that may provide short-term benefits but ultimately increases vulnerability to future change' (ibid). Nevertheless, well-designed insurance schemes can be effective reactive economic adaptations, especially in the face of disastrous extreme events such as flooding, which few practical, on-farm interventions can protect against. Additionally, if the price of premiums is linked to the implementation of physical risk management interventions, resilience building can be incentivised (Hielkema 2023). Notwithstanding, insurance should only be promoted within 'the right mix' of interventions which also include a stronger focus on transformative adaptations.

In most cases, the practices with an identified maladaptation risk in the inventory are those which increase energy and/ or water dependency (presenting a risk of rebound vulnerability), insurance options which can incentivise risky behaviour (presenting a risk of rebounding vulnerability), those which could reduce water availability for other farmers (presenting a risk of shifting vulnerability), and those which may require increased use of pesticides or fertilizer (presenting a risk of negative externalities). To reiterate, an identified maladaptation risk does not necessarily constitute a blacklisting of practices of any adaptive potential, as they may be suitable in certain situations, but if there are other effective options which present pathways of lesser risk, these should be prioritised.

On the other hand, changes in practice which pose less risk of maladaptation tend to be those which represent agroecological principles of input reduction, promotion of natural recycling of soil nutrients, diversification and promotion of biological synergies (FAO, 2018). Another core principle of agroecology is that of co-creation and knowledge sharing, which aligns well with the suitability factors outlined in this study, including equitable uptake potential and the fostering of enabling conditions.

Organic farming, which shares many of the principles and practices associated with agroecology likely avoids maladaptive consequences if implemented correctly. The focus on soil fertility and permanent soil cover increases resilience to erosion, flooding and water scarcity (Pimentel et al., 2005; Sanders

and Heß, 2019). One interviewee highlighted how the inability to use pesticides or fertiliser incentivises breeding for resilience, as farmers need to use species and varieties which offer enhanced disease tolerance, rooting depth and water-use efficiency.

2.3 SQ3: What main factors in the short and long term, have been affecting farmers' decisions to adapt their farming practices to CC?

The analysis reveals the complex and interconnected roles of various dimensions in driving change at the farm level. Among these dimensions, material aspects, meaning and sense, and social norms emerge as particularly influential. Farmers' perceptions of CC impacts and their personal experiences of production losses act as key driver in terms of decision to adapt. Financial aspects are also an important factor, especially when new practices are expected to result in negative financial impacts, or when the economic uncertainty related to these new practices is high. Finally, the availability of specific innovative equipment can be pivotal to implement innovative practices in a specific sector or a specific area. This may be tackled by relevant public support or by the implementation of studies and the dissemination of results. Additionally, limited coordination between authorities and complex administrative procedures may act as significant barriers for the decision to implement a change. Social norms on implementation of new practices are also key. In this context, information and advice networks can play an important role. Aspects relating to farmers skills have been identified in the literature but not highlighted in the farmers' survey and case studies.

This research question seeks to identify the key factors influencing farmers' decisions to implement adaptive practices in response to or in anticipation of CC. The methodology is adapted from 'Practice theory', developed by Schatzki³⁰, which provides an analytical framework to examine how various social, material, and personal dimensions interact to shape the emergence and implementation of changes in farming practices in the long term. The literature (Brown et al, 2021) highlights that farmer decisions are often understood in a simplistic way, focusing on financial aspects, where other mechanisms are at play, covering a broad range of social, attitudinal and contextual factors.

The main drivers affecting farmers' decisions in changing practices relate to the following dimensions:

- The meaning and sense given by the farmer to the adaptation practice, which relates to perceived climate risks, personal experience, and environmental awareness;

³⁰ This theory is detailed in the research by Roques and Roux (2018) - <https://shs.hal.science/hal-02022162/>

- Material aspects including both equipment challenges (availability and costs) and adequate financial support (expected benefits, adequate support, and administrative burden);
- Individual capacity comprising of the skills, knowledge, training and support required to implement a change;

Social norms, linked to the cultural patterns of the territorial, professional, and personal communities within which farmers operate. The regulatory context is also considered in this dimension of 'social norm' as it covers different levels of the regulatory framework (EU, national, regional) as well as the degree of enforcement of each regulation (strict enforcement with controls and sanctions or low enforcement). These norms may function either as catalysts or as barriers to change, influencing the extent to which farmers are willing or able to adopt new practices.

The findings presented in this section are based on the analysis of relevant literature, case studies, interviews and quantitative data from the farmer survey. To understand both the drivers and barriers related to the uptake of CCA, survey respondents were asked to rate the reasons influencing their decision to implement, or not to implement, CCA. However, it is important to note that the farmers' survey data is not fully representative and should not be generalised due to uneven distribution of responses by country and limited sample size.

This section provides findings for the following outputs:

- General overview of main drivers and barriers;
- An assessment of the extent to which each dimension acts as a barrier or driver for farmers to adapt to CC.

2.3.1 Drivers encouraging farmers to adapt

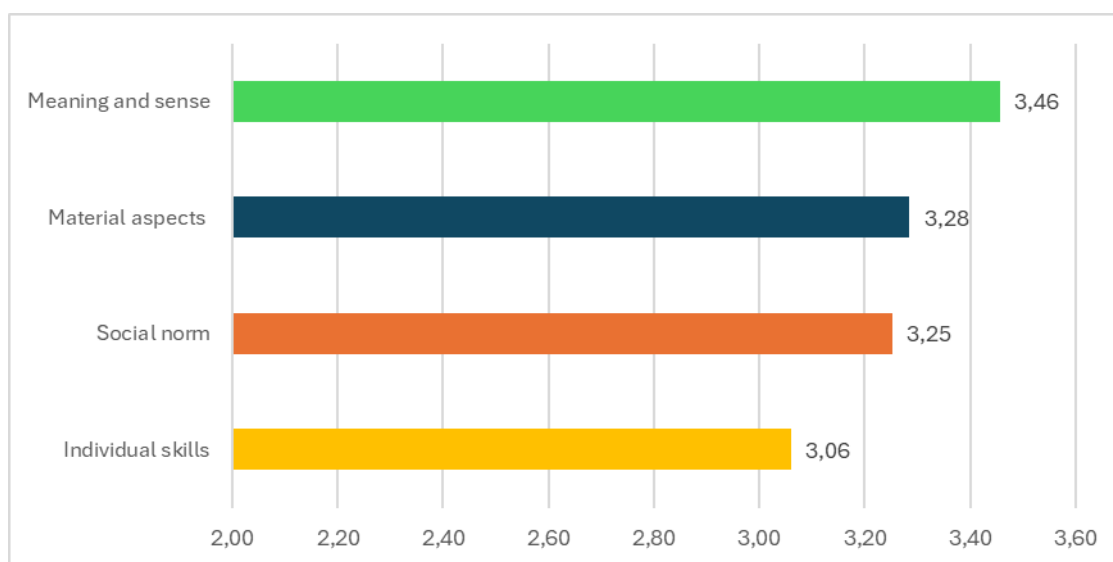
2.3.1.1 Relative importance of each dimension for farmers

In the online farmer survey, sixteen statements were presented to farmers who had reported having carried out some adaptation on their farm in response to or in anticipation of CC. These statements are related to a dimension (meaning and sense, social norm, material aspects and individual skills). Analysis has been conducted to understand the importance of each dimension for farmers³¹. Among the four dimensions, 'meaning and sense' is the most important, followed by 'material aspects' and 'social norms'. These three dimensions are

³¹ A series of statements were presented to respondents, each accompanied by a five-point Likert scale ranging from 'very important' to 'not important at all'. A numerical value was assigned to each response category: 'Very important' was allocated a value of 4, 'Important' a value of 3, 'Neutral' a value of 2, 'Not very important' a value of 1, and 'Not at all important' a value of 0. Each respondent's selection was then attributed its corresponding numerical value. For each statement, these values were summed and then divided by the total number of responses to calculate the mean score. This analysis was conducted using weighted data, as explained in section 1.4.2, therefore the formula used to calculate the weighted mean score was: $\text{Weighted mean score} = (\text{Sum of [response value} \times \text{weight]}) / (\text{Sum of weights})$

particularly influential in motivating changes to better adapt to future climatic conditions. In contrast, 'individual skills' are perceived as less critical by farmers; this result may reflect that while skills may be identified as a driver by external analysts (researcher, academics), that is less so in a self-assessment made by farmers. Figure 6 shows the score for each dimension, each represented by a different colour.

Figure 6. Drivers- Weighted aggregated mean score grouped by dimensions³²



Q23 Farmers survey. 'Which, if any, of the following reasons did you consider for taking measures to cope with future weather challenges?' (Proposed choices have been grouped under the four dimensions above). Base n= 118 of 334. Weighted using UAA data.

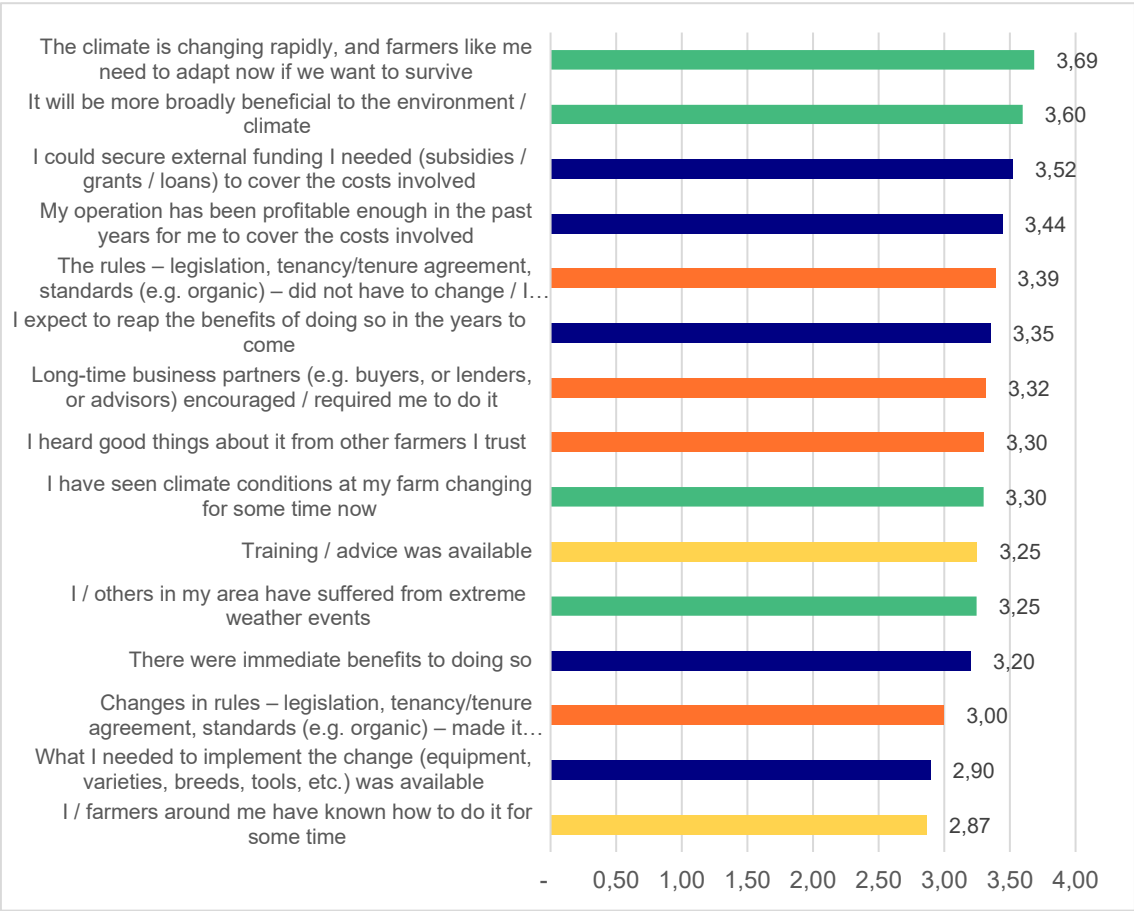
Among the sixteen possible drivers indicated to farmers, most of them (87.5%) were considered important (score above three on a scale of four). In addition, most of the drivers are considered equally important, with a standard deviation of low magnitude (0.17). The three most influential drivers of change identified span two distinct dimensions which highlight the combination of drivers necessary to implement change at farm level:

- **Meaning and Sense:** 'The climate is changing rapidly, and farmers like me need to adapt now if we want to survive' received a mean score of 3.68, indicating that farmers who made adaptations have a precise awareness of the necessity of adaptation in the face of CC. In addition, the driver 'It will be more broadly beneficial to the environment/climate' with a mean score of 3.60, reflects farmers' recognition of the broader environmental benefits associated with adaptation practices.
- **Material Aspects:** 'I could secure the external funding I needed (subsidies/grants/loans) to cover the costs involved' scored 3.52 on

³² Each dimension is represented by a colour ('Meaning and sense': green, 'Material aspects': blue, 'Social norms': orange, 'Individual skills': yellow). These colours are used throughout this section to indicate the dimension each statement relates to.

average, underlying the importance of financial support in enabling the implementation of adaptive measures.

Figure 7.Drivers-Individual weighted mean score by dimensions



Source: farmers' survey. Q23. 'Which, if any, of the following reasons did you consider for taking measures to cope with future weather challenges?' (Proposed choices have been grouped under the four dimensions above). Base n= 118 of 334. Weighted using UAA data. N.B. Each dimension is represented by a colour ('Meaning and sense': green, 'Material aspects': blue, 'Social norms': orange, 'Individual skills': yellow).

2.3.1.2 Details on each driver

Meaning and sense

Farmers' perceptions of CC risks and their own past experiences significantly shape the meaning they attribute to adaptation practices. Those who have directly experienced extreme weather events, such as droughts, unseasonal frosts, or heatwaves tend to develop a heightened sense of climate vulnerability, which in turn fosters a stronger commitment to adaptation (Hinzmann et al., 2021; Ibrahim and Johansson, 2022). Farmers who perceive CC as a human-induced threat are also more inclined to proactively consider adaptation (Galdies et al., 2016; Valencia Cotera, Egerer, and Máñez Costa, 2022). As Allart et al (2024) show, when farmers appraise climate risks as high and simultaneously feel capable of managing them, they are more likely to plan

and implement adaptive changes. Similarly, Iglesias et al. found that farmers they categorised as 'alarmed' or 'conscious and committed' were significantly more supportive of adaptation options (Iglesias et al., 2021).

The farmer survey highlighted that the expected benefits for the environment and/or for the farm (for instance, improvement of animal welfare during heatwaves, improvement of water management) were important drivers to implement changes. The case studies also identified the importance of personal conviction to adapt to CC. This related to direct experiences of climate-related losses. In this context, drought and heatwaves were considered the main CC impacts to cope with. Some farmers also mentioned the desire to farm in a way that delivers benefits for the environment and the climate. For processors in the dairy sector, helping farmers implement adaptation strategies also leads to a direct reduction in GHG emissions. This can be communicated in the context of company's carbon strategy and may act as a driver for processors to promote on-farm adaptation strategies (indicated in an interview with a large-scale company in the dairy sector in France).

The following examples have been identified in case studies:

- In Emilia-Romagna, farmers adopt soil bio restoration practices to address soil fertility loss exacerbated by extreme precipitation events;
- The increasingly frequent losses caused by drought triggered the adoption of new production methods in all case studies, such as in Wielkopolskie (sorghum production to replace corn, low tillage practice), Upper Austria (drought resistant grassland), Emilia-Romagna (soil bio restoration), Catalonia (reusing rainwater for pig production) and Pays-de-la-Loire (grouped calving in Autumn, hedgerows to protect animal welfare in case of high temperature).

Material aspects:

The material dimension of adaptation is grounded in:

- The challenges of accessing, affording, and maintaining equipment and the infrastructure required for change. For instance, in a survey conducted among 352 wine growers and farmers in southeastern France (Languedoc- Roussillon), those with access to irrigation infrastructure or those using mixed irrigation methods are significantly more inclined to adapt their water management strategies due to better understanding of the vulnerability of water resources, water use restrictions and increased cost (Graveline and Grémont, 2021);
- Financial aspects. These include the additional costs related to new farming practices, and the profitability of a new system of production. In a research paper by Hinzmann et al., 50 farmer interviews were conducted in Western and North-East Germany on the acceptance and willingness to adopt two alternative subsoil amelioration techniques (alfalfa cultivation vs deep loosening with incorporation of compost (DLC)). It

was found that financial considerations, such as, positive cost-benefit ratio was key for successful implementation, as well as the availability of subsidies and government incentives to encourage farmers to cultivate alfalfa, for which no attractive market exists (Hinzmann et al., 2021).

The farmers survey highlighted that self-financing capacity and availability of external support (subsidies) were pivotal for farming practices which required specific physical investments, such as precision farming or investments in animal buildings. The availability of information on the profitability of new practices (costs and benefits) is also important for farmers to decide to implement a change. The access to equipment is also key (and may be challenging) to implement innovative practices. In the case studies, material aspects were assessed as important to implement adaptation measures. This may be related to the potential economic profitability of adaptation measures (lowering yield uncertainty, decreasing costs in the long term), financial support provided by public authorities and regulatory aspects (for instance, irrigation rules). In more detail:

- The potential economic benefits of adaptation can be either related to the reduction of yield and production uncertainty under CC (Upper Austria) or with a specific market demand for agri-food items with more sustainable practices (Emilia-Romagna);
- Water-saving infrastructure, precision tools, and training programmes are supported by public programmes (Emilia-Romagna);
- In Pays-de-la-Loire, the financial support for collecting rainwater from greenhouses has been mentioned as key to investment. The plantation of hedgerows also provides wood for heating and litter for animals;
- The development of conservation tillage, including reduced/no tillage and mulching/permanent soil cover, is also supported by CAP eco-schemes as carbon farming and simplified systems in Wielkopolskie.

Social norms

Farmers' adaptation behaviours are also shaped by the social norms embedded within their territorial, professional, and personal communities. Membership of cooperatives, consortia, or professional associations has been linked to higher adaptation uptake, as these groups often coordinate collective strategies and offer advisory support (Pagliacci and Salpina, 2024). Social networks also provide informal learning and influence, with a study showing that farmers embedded in active knowledge-sharing groups are more likely to implement adaptive practices (Nguyen, Seddaiu, and Roggero, 2019). In regions where cultural narratives prioritise resilience, heritage conservation, or environmental stewardship, such as in Tyrolean Mountain agriculture (Austria), social norms can reinforce adaptation. For example, the Tyrolean Genebank conserves traditional crop varieties not for climate reasons but to protect cultural heritage and biodiversity, yet this increases resilience by maintaining genetic diversity

suited to harsh mountain conditions. Similarly, organic farming promoted through the 'Bio vom Berg' label reflects strong environmental values around animal welfare and landscape care, while also improving soil health and reducing market dependence. (Grüneis et al., 2018).

The role of 'social norms' has been highlighted as an important driver in the context of the farmer survey. For instance, this was observed among farmers who implemented organic production, which is an important shift in the production system. From a general perspective, the positive feedback received by other farmers on a practice was also identified as a significant driver from the farmer survey.

In the case studies mentioned below, collective field visits and exchanges with farming neighbours are considered to play an important role in the deployment of new practices. Improving farmer's image in front of the consumers by promoting innovation and effective communication of good farming practices by producer organisations or localities can also drive climate-adaptive strategies. In addition, water and agriculture policies, along with private contracts, play a significant role in driving change by providing rules for water abstraction, irrigation scheduling, and environmental protection. They can either enable or constrain the adoption of CC adaptive farming practices. In more detail:

- In Wielkopolska, farm visits were a particularly important driver to make the social norm evolve;
- In Catalonia, farmers expressed that the implementation of farming practices relevant for CC adaptation could have an impact on society (this point is relevant for both 'meaning and sense' and 'social norms');
- Some French farmers from Pays de la Loire viewed being pioneers in implementing innovative techniques as a motivating and rewarding challenge.

Individual skills

Farmers' individual capacities, comprising their knowledge, technical skills, and access to advisory support, are key in shaping their ability to adapt. A formal education in agriculture or a high level of agronomic and ecological knowledge correlates with greater adaptive intention, especially in the case of complex practices like managing permanent grasslands (Allart et al., 2024). For instance, in an online survey administered in the Veneto Region of Italy to 137 agri-food GI producers, 90% of respondents reported having experienced CC impacts, but only 24% have adopted some type of adaptation measure, and 33% are planning to adopt them in the future. The factors influencing farmers' willingness to adapt were analysed using statistical models among which education level was found to be the most significantly positive, i.e. farmers with a high school degree in agriculture show a greater willingness to adapt (Pagliacci and Salpina, 2024). Similarly, engagement with advisory services and peer networks

was found to be important in building farmers' confidence and competence to act (Ibrahim and Johansson, 2022).

In the case studies, individual skills were generally not perceived as an important driver by most of the stakeholders interviewed. However, case studies from France and Poland suggest that technical learning can act as a catalyst for adopting new practices. Equipment demonstration, experimental farms and dissemination of R&D projects are providing examples of enabling change in practices (identified in Pays de la Loire, Wielkopolskie, Emilia-Romagna)

Others

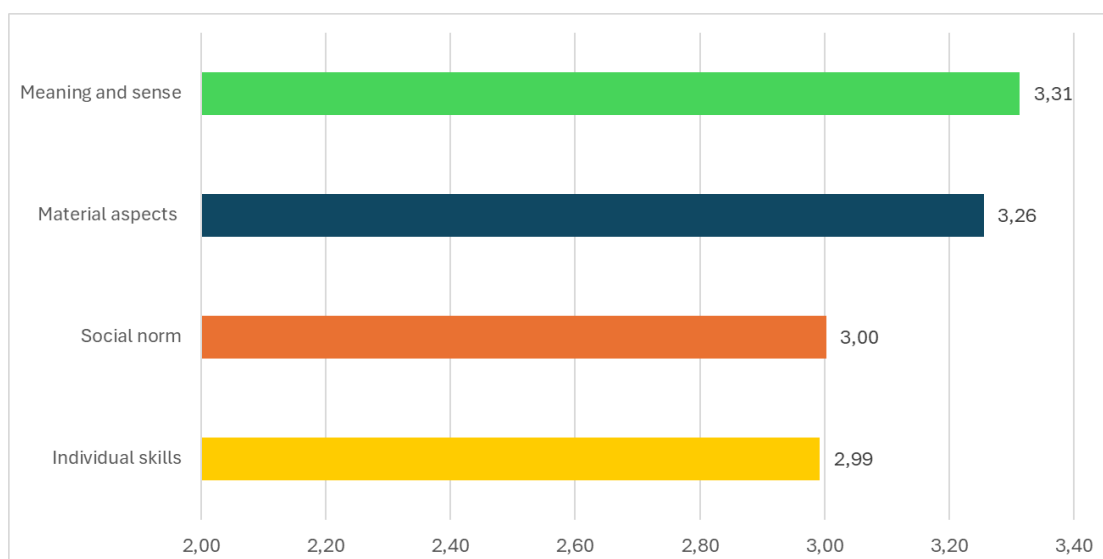
The presence of diversified landscapes, including tree cover or mixed farming systems, is positively associated with openness to climate-resilient practices (Bonzanigo et al., 2016). Technological innovations, such as precision agriculture and digital tools, can also foster environmentally conscious decision-making (Valencia Coterá, Egerer, and Máñez Costa, 2022). Intergenerational renewal may serve as another catalyst, with younger farmers often more inclined toward sustainable transitions (Allart et al., 2024).

2.3.2 Main barriers for farmers to adapt

2.3.2.1 Relative importance of each dimension for farmers

The key barriers identified by farmers who reported not having taken any steps at their farm to adapt to CC show the predominant weight of 'meaning and sense' and 'material aspects' over the other dimensions. 'Social norm' and 'individual skills' are identified to a lesser extent by farmers as barriers.

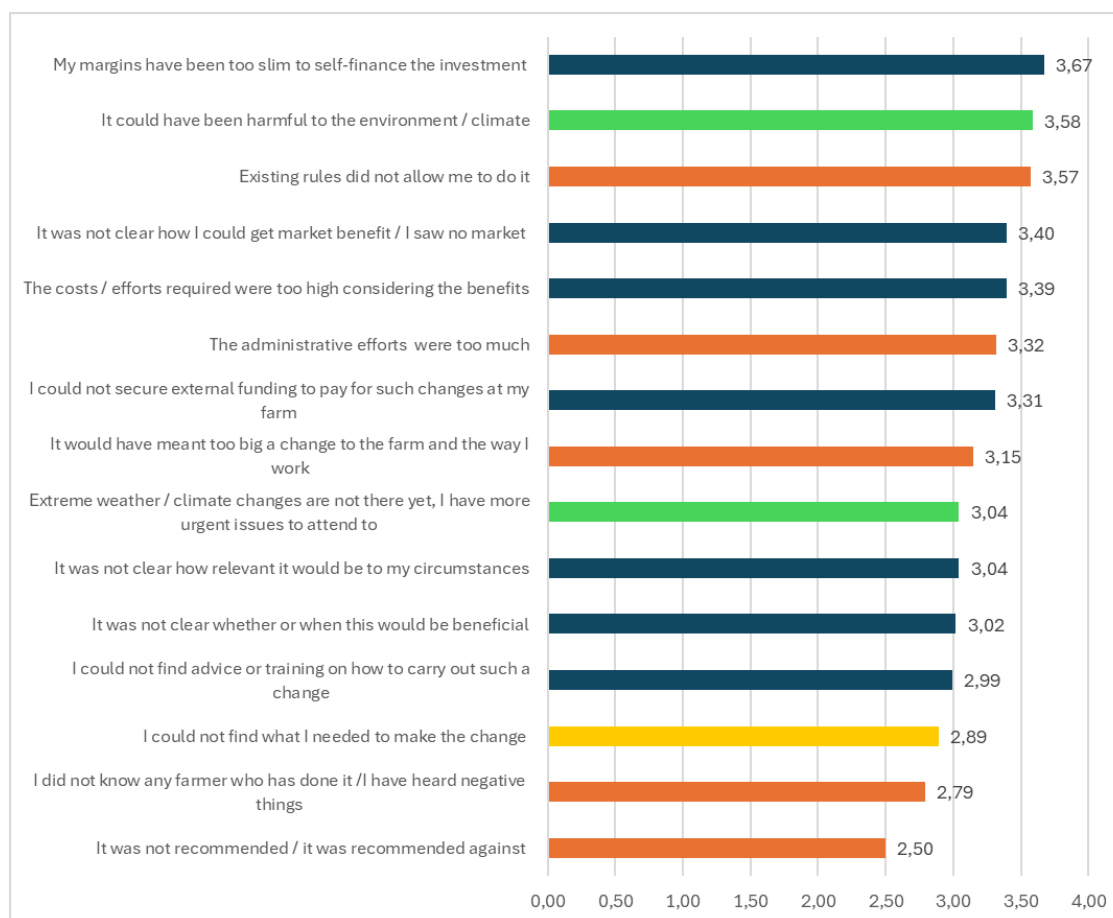
Figure 8. Barriers- Weighted aggregated mean score grouped by dimension



Source: farmers' survey. Q24. 'How important to you were the reasons listed for not taking step(s) to better cope with future weather problems at your farm?' (Proposed choices have been grouped under the four dimensions above). Base n= 216 of 334. Weighted using UAA data. N.B Each dimension is represented by a colour ('Meaning and sense': green, 'Material aspects': blue, 'Social norms': orange, 'Individual skills': yellow).

As detailed in the previous section on 'drivers', farmers were asked to score sixteen specific barriers to implement CC adaptation measures (each related to 'meaning and sense', 'material aspects', 'social norm' and 'individual skills'). While the weighted mean scores for drivers appeared relatively consistent, the scores for barriers showed greater variability, with a standard deviation of 0.27. Notably, four barriers were considered of low importance, each receiving a mean score below three. The three most significant barriers (with mean score above 3.50) relate to 'material aspects', 'meaning and sense' and 'social norm':

- 'My margins have been too slim to self-finance the investment' (mean score: 3.67);
- 'It could have been harmful to the environment/climate' (mean score: 3.58);
- 'Existing rules did not allow me to do it' (mean score: 3.57).

Figure 9. Barriers- Individual weighted mean score grouped by dimension

Source: farmers' survey. Q24. How important to you were the reasons listed for not taking step(s) to better cope with future weather problems at your farm? Base n= 216 of 334. Weighted using UAA data. N.B. Each dimension is represented by a colour ('Meaning and sense': green, 'Material aspects': blue, 'Social norms': orange, 'Individual skills': yellow).

2.3.2.2 Details on each barrier

Meaning and sense

The meaning farmers assign to CC and adaptation is often influenced by scepticism, low perceived risk, or a fatalistic worldview. These are major barriers to action. In several studies, farmers expressed doubt about the human causes of CC or minimised its urgency, reducing the likelihood of implementing adaptive practices (Pagliacci and Salpina, 2024; Ricart, Olcina, and Rico, 2018; Valencia Coterá, Egerer, and Máñez Costa, 2022). Others, particularly older farmers or those close to retirement, exhibited fatalism, believing that adaptation was either futile or irrelevant given their remaining time in farming (Allart et al., 2024; Morel and Cartau, 2023). This mindset is often reinforced by religious beliefs, denial, or psychological distance, where CC is perceived as a distant issue, not warranting immediate attention (Iglesias et al., 2021; Mitter et al., 2019).

In the case studies, the inherent uncertainty regarding climate projections perceived by farmers is identified to inhibit long-term planning. In addition, misinformation about CC and perception of unbalanced efforts regarding water use is discouraging adaptation. The fear of a regulatory ‘ratchet effect’, where a reduction in water consumption could lead to a decrease in their quotas, discourages water saving efforts. Lastly, older farmers (close to retirement) may hesitate before investing. In more detail:

- Misinformation that underestimates potential CC impacts discourages farmers from adopting new practices has been identified in Pays de la Loire and Wielkopolska;
- In Pays de la Loire, the development of water abstraction for tourism is perceived as unbalanced and unfair by some stakeholders, limiting the willingness to implement change;
- In Catalonia, an ageing farming population and lack of generational renewal impede investments and changes in farming practices;
- The dairy industry in France reported that farmers over 55 years old may be reluctant to change their ways so close to retirement.

Material aspects

Material limitations, particularly financial ones, are among the most frequently cited barriers to adaptation. High upfront costs, lack of credit access, and uncertainty about returns on investment deter farmers from adopting measures such as irrigation systems, crop diversification, or soil enhancement techniques (Gruère, 2017; Pagliacci and Salpina, 2024; Valencia Coterá, Egerer, and Máñez Costa, 2022). The administrative complexity of accessing public funds (e.g., EU rural development programmes) further limits uptake, especially among smallholders who often lack technical assistance (Mandryk et al., 2015; Pagliacci and Salpina, 2024). Insecure land tenure and lack of ownership discourage long-term investments (Kopytko and Pruneddu, 2018; Wiréhn et al., 2020), while the perceived economic risks of adapting on rented land or with uncertain market returns disincentivise farmers from innovating (Gütschow, Bartkowski, and Felipe-Lucia, 2021). Additionally, incompatibility with existing infrastructure such as irrigation systems designed for traditional crops can make change impractical or cost-prohibitive (Graveline and Grémont, 2021; Valencia Coterá, Egerer, and Máñez Costa, 2022). Even when financial support is available, the perceived administrative burden and complexity can create a ‘low-hanging fruit paradox,’ where seemingly simple changes remain out of reach (Grüneis et al., 2018).

In the case studies, initial and maintenance costs of CCA are significant barriers, especially for small and medium-sized farms, and the benefits resulting from the implementation of some practices such as nature-based solutions are difficult to measure. The uncertainty related to the economic outcomes of

transitioning away from conventional farming systems, combined with the lack of empirical evidence, makes the decision risky for farmers across all the regions analysed.

A lack and inadequacy of public financial support is also identified as an issue. Specific subsidies for certain practices, such as planting drought-resistant varieties in the wine sector in some regions in Spain, are often non-existent and may even limit the access to other support programmes if they include a pre-defined list of varieties. This may also have an impact on the possibility to be involved in geographical indications (this point is developed in the subsection on 'social norms').

The complexity of the institutional framework and perceived limited coordination between agricultural and water management authorities is a major obstacle to integrated planning and action. Farmers highlight complex, time-consuming, and uncertain administrative procedures for accessing financial aid and authorisation. Programme requirements can change, creating uncertainty and delays or leading some farmers to make investments without proper documentation. From a general perspective, lack of coordination and data gaps are identified as important barriers in several areas covered by case studies, in particular on water management.

In more detail from the case studies:

- The uncertainty related to the economic outcomes of transitioning away from conventional farming systems, combined with the lack of empirical evidence, makes the decision risky for farmers across all the regions analysed;
- In Upper Austria, constructing on-farm reservoirs or storage ponds needs two independent permits when usage exceeds private and minimal farm needs: one for water abstraction and one for construction of the pond, which interacts with groundwater or natural watercourses. Both processes can require expert documentation and environmental evaluation and will take 6-18 months.
- In Wielkopolska, on the contrary, drought emergency compensation is considered as counterproductive by some stakeholders as it does not incentivise farmers to change their practices;
- With regard to other structural factors, in Emilia-Romagna, short-term land lease contracts discourage long-term investments in soil and water conservation. In Pays de la Loire, farm enlargement is considered as a major obstacle for agroforestry development because its maintenance requires time and a workforce.

Social norms

Social and cultural norms embedded in local farming communities often function as barriers on adaptation. In many cases, traditions and the identity of being a

‘good farmer’ are tied to continuity and resistance to external influence, making innovative practices feel threatening or illegitimate (Gütschow, Bartkowski, and Felipe-Lucia, 2021). Farmers embedded in professional cultures that prioritize individualism, such as owning all machinery or working independently may avoid collaborative or more sustainable practices (Ibrahim and Johansson, 2022). Farmers operating in fragmented territories or weakly organised networks lack the peer reinforcement and collective strategies that help normalise change (Pagliacci and Salpina, 2024). In many cases, these norms create a form of ‘avoidance culture,’ where conservatism and reliance on past experience crowd out innovation (Mitter et al., 2019).

In the case studies, social disapproval and a lack of understanding from other farmers on the need to adapt are identified as obstacles. Reluctance to change long-established practices and strong ties to local traditions act as barriers. The regulatory framework may also be considered as a barrier, for instance in the case of geographical indications with farming practices defined in code specifications registered at national and EU level. An update of this code of specification (with new farming practices) requires an administrative procedure.

In more detail from the case studies:

- In Catalonia, the implementation of regenerative agriculture and specifically permanent soil cover in vineyards was met with scepticism by some farmers;
- In Pays-de-la-Loire, farmers’ identities are closely linked to the farm model they have built, making potential transformational change difficult to accomplish;
- In France, the dissemination of practices beyond pilot groups of farmers (15-20 farmers) is a great challenge (identified in the milk sector);
- The EU vineyards are widely involved in geographical indications (such schemes are also found in other agricultural sectors, such as cheese and meat production). Changes in farming practices which are linked to the geographical indications specifications ask for specific procedures.

Individual skills

A study noted that farmers often evaluate adaptation negatively when they feel the costs outweigh the benefits or when they lack the skills to implement changes (Mitter et al., 2019). Farmers who perceive themselves as having minimal capacity due to farm size, lack of successors, or poor education are also less likely to adapt (Mitter et al., 2019; Morel and Cartau, 2023). A weak advisory system and top-down governance models further undermine farmers’ confidence, especially when they feel their input is ignored or when guidance is regulatory rather than collaborative (Ibrahim and Johansson, 2022).

In the case studies, the lack of specific training and insufficient advisory support were identified as barriers for development of new practices. In addition, older farmers find it more difficult to adopt new technologies than younger ones. In more detail:

- In Emilia-Romagna, soil bio-restoration lacks experimental and demonstration activities to disseminate relevant information to farmers;
- In Catalonia, stakeholders interviewed reported that an ageing farming population is reluctant to change practices when this is related to new technologies.

Others

Distrust in institutional actors including policymakers, advisors or scientists also weakens the influence of externally promoted practices (Hinzmann et al., 2021; Iglesias et al., 2021). Meanwhile, policy-related barriers such as misaligned subsidies, rigid regulatory frameworks, or the perceived irrelevance of top-down strategies often clash with local farming logics (Trnka et al., 2022; Wiréhn et al., 2020).

2.3.3 Findings on the barriers or drivers of change

Each dimension of the ‘theory of practices’ may act as a barrier or a driver depending on the farming practices and the farm context. In the context of adaptation of farms to CC, ‘meaning and sense’ and ‘material aspects’ play the most important role. ‘Social norms’ were also identified as a key aspect, while individual skills appear as less challenging.

With regard to ‘meaning and sense’, the awareness of CC impacts is pivotal to implement adaptation measures. This is highly related to personal experience of farmers and the exposure to specific climatic events (heatwave, drought...). These events may be a tipping point to implement specific adaptation measures. This implies that other dimensions are also fulfilled: possible over-costs are compensated by a price premium or public funding is available, practices are perceived to be in line with social norm.

When ‘material aspects’ are reported as a driver, the access to external funding or the capacity to self-finance a project may be a tipping point (this implies that other dimensions are already fulfilled, such as the awareness on the impacts of CC). The expected benefits are also important for farmers to implement an adaptation measure. In this context, the development of new farming practices and the dissemination of information may be tipping points for farmers.

In terms of barriers, ‘meaning and sense’ includes both types of farmers:

- Farmers who consider that the impacts of CC are not significant enough on their farm to adapt;
- Farmers who are aware of the CC impacts and are seeking to implement farming practices relevant for climate and environment (this implies that they are not convinced of the relevance of the farming practices developed so far).
- Thus, the availability of relevant and reliable information is key for farmers to assess 1) the possible impacts of CC at the level of their farm and 2) to assess the impacts of the farming practices on the environment and climate. The dissemination of relevant information may be a tipping point for farmers to implement a change.

When 'material aspects' is reported as a barrier, the difficulties for farmers to self-finance the projects is highlighted. This is related to the possible difficulties to access bank credits and the possible absence of adequate public support to compensate over-costs or support investments. The impact of this dimension strongly varies depending on the type of practices considered, the type of equipment needed, its costs, the availability of studies on the expected costs and benefits, the existence of specific equipment, etc.

Social norms play a significant role in farming and perceived unconventional practices may be met with scepticism or disapproval. Literature review highlights the importance of this dimension as both a driver, in case of involvement in an innovative group of farmers (small group or a large-scale cooperative) and a barrier when social norms increase the resistance to external influence. The farmer survey also highlighted that the implementation of a new practice by farmers in the area was a driver for a farmer, as well as positive feedback received by other farmers. 'Social norm' is specifically challenging when adaptation measures are particularly innovative compared to the common practices. In addition, the regulatory framework may also be a barrier, such as for geographical indications where farming practices are stated in a code of practices, and any change in practice (adaptation measures for instance) requires a cumbersome revision of the code beforehand.

Both the farmer survey and case studies show that 'individual skills' play a limited role in motivations to adapt or not. However, the literature review highlighted the importance of this dimension to implement new practices at farm level. This low magnitude observed in case studies and the farmer survey may be related to the inability of farmers to objectively assess their own skills and the need for training.

2.4 SQ4: What are the costs and benefits of the implementation of good strategies and practices to adapt farms to CC?

The analysis shows that several adaptation practices deliver clear agronomic and economic benefits without requiring significant investment or public support. Practices such as crop rotation, crop diversification, and the use of cover or catch crops generally involve low or no upfront investment, and their operational costs are typically offset by improved yields, better soil quality, and reduced input needs. By contrast, a second group of practices generates strong environmental and long-term resilience benefits but requires a transition period during which farmers may face initial yield reductions or higher costs. Examples include conservation or minimum tillage, adjusting calving periods, introducing new species, breeds or varieties, and establishing agroforestry systems such as hedgerows or silvopasture. While these practices are highly beneficial over time, they often demand technical adjustments, learning, or upfront investment that can challenge farm profitability in early years. Finally, some practices are highly context-dependent, with their economic viability varying according to climatic conditions, crop type, water availability, and farm structure. Rainwater harvesting, drip irrigation, and multifunctional nets can be highly effective in specific environments, particularly in drought-prone or high-value crop systems, but their high capital costs and variable benefits mean that support needs and uptake potential differ significantly across regions.

2.4.1 Cost and benefits of adaptation at farm level

This study question presents a cost-benefit assessment of **27 good practices**. These practices were chosen from the inventory of practices developed as part of the study, based on the following criteria: (i) availability of cost and benefit data in the primary and secondary evidence collected; (ii) suitability criteria under 2.2 (low risk of maladaptation); (iii) expert consultations with ABCIS (French Technical Institute for livestock) and online workshop 2 (See section 1.4.3).

Based on the EEA report on the costs of adaptation versus the costs of inaction (2022), **the primary benefit of CCA measures is the avoidance of damages** and losses in the short, medium and long term, such as the direct and indirect damage to crops, infrastructure or assets on the farms, which are likely to occur if no action is taken to adapt to CC. While the costs resulting from recent extreme events can generally be assessed, at least approximately, in terms of production losses, the overall risk exposure³³ to climate events is a lot more

³³ The EIB Fi-compass study categorises farm-level risk into three categories: (1) high frequency, low intensity events; (2) medium frequency, medium intensity events; (3) low frequency, high intensity events. Farms are exposed to

difficult to assess, and the cost of structural CC, in terms of yield reduction in particular, is generally not known, as yields are affected by other factors and vary from year to year (Debaeke et al., 2025). CCA measures can also provide **other economic benefits** (e.g. improved yields, reduced input consumption), as well as environmental co-benefits, including the positive effects on biodiversity, air quality, reduced greenhouse gas emissions (from livestock in particular), carbon sequestration, improved soil quality, etc.

Costs of adaptation include on-off costs (e.g. initial inputs, equipment, labour costs resulting from changing the work organisation) and **recurrent costs** (e.g. additional labour costs, input costs, yield reduction).

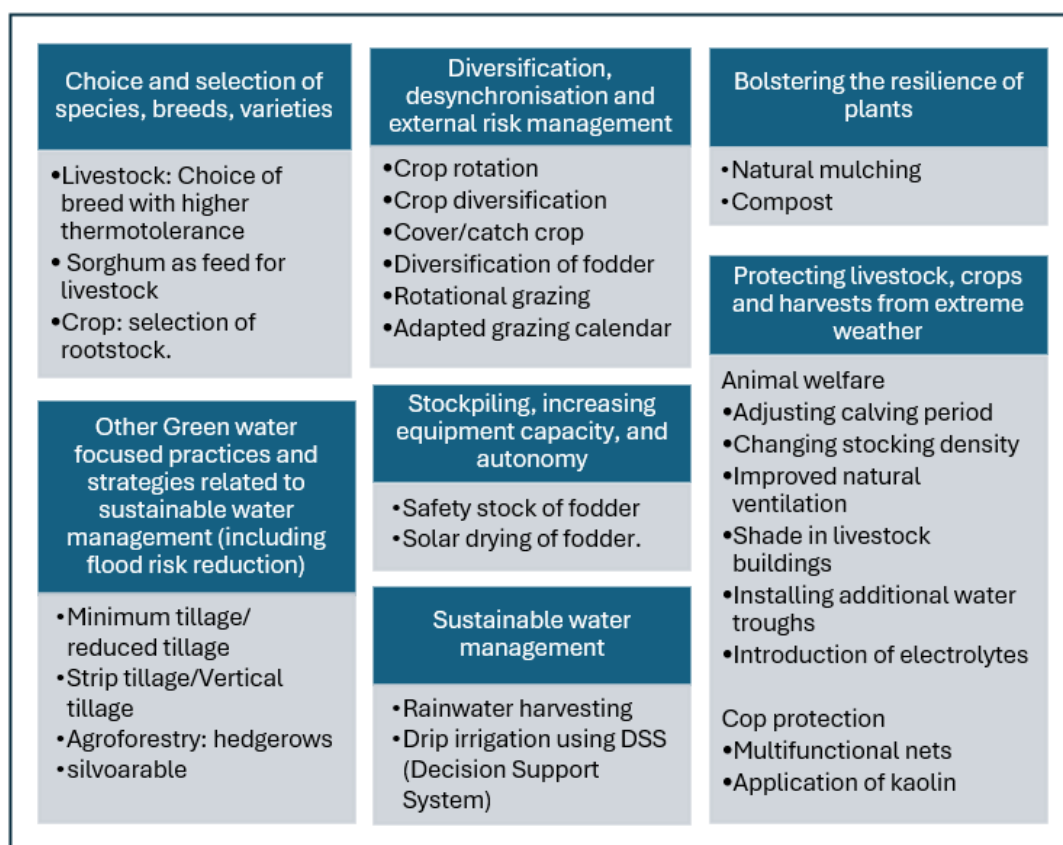
Adaptation costs and direct economic benefits can be estimated to some extent using a mix of quantitative and qualitative information from the literature, desk research, case studies and the farmer survey. Available data do not allow to quantify avoided damages or environmental co-benefits at farm level, in the latter case, partly due to difficulties in isolating their effects and the uncertainty about when benefits will be realised, but a qualitative assessment is provided, based on the existing literature.

The main results are presented here by broad categories similar to SQ1 (Section 2.1), with a general assessment of costs versus benefits. The analysis relies on a mix of quantitative and qualitative information from the literature, desk research, case studies and the farmer survey³⁴. A detailed CBA analysis, including Net Present Value (NPV) was calculated using the Better Regulation Toolbox³⁵ for five practices (Agroforestry (hedgerows and silvoarable), rotational grazing, minimum tillage, catch/cover crops, and sorghum as feed) among the 27 practices selected under this SQ. For economic acceptability, NPV must be positive; the higher the NPV the more desirable the practice is.

different risks where losses can be much higher in a specific year, with large intra-EU variations depending on the sector and geographic area. Agricultural droughts are more frequent in Southern Europe but cause less damage than low frequency, high intensity hail/frost/floods events.

³⁴ When available, data from the ADA Life project (S. De Leo et al, Climate change in agriculture: A cost-benefit evaluation of adaptation measures, 2024) is used as the main source, adjusted to 2023 EU prices (based on Eurostat series for agricultural prices and Eurostat price index). The WOCAT database ([WOCAT](#)), case studies and farmers' survey are used to provide additional detail.

³⁵ https://commission.europa.eu/law/law-making-process/better-regulation/better-regulation-guidelines-and-toolbox_en

Figure 10. Good practices selected for analysis under SQ4

Choice and selection of species, breeds, varieties

Following SQ1, we analyse here the costs and benefits of changing practices by strategic selection of crop species, breeds, and varieties, which can improve farm resilience. In livestock systems, farmers can opt for **breeds with greater thermotolerance** to adapt to growing heat stress in the southern and central EU. In forage systems, **drought-tolerant species such as sorghum** are being grown by farmers instead of maize. In perennial crops, the **choice of rootstock** can help achieve long-term resilience and better fruit quality.

For dairy cattle, many indigenous or thermotolerant breeds are naturally better adapted to hot environments, resulting in lower heat stress, improved fertility, and reduced mortality rates compared to highly specialised dairy breeds such as Holstein. However, these adaptive advantages come with a trade-off, as indigenous breeds generally produce less milk, representing an opportunity cost in terms of foregone productivity (Misztal, Brito, and Lourenco, 2025). There is no direct investment cost, but it does entail a recurring additional input cost for the purchase of semen, typically EUR 20-50 per dose, or EUR 50-150 per head annually for 2–3 inseminations. The **direct benefits**, such as improved fertility and reduced mortality are difficult to quantify, as they depend heavily on farm-specific housing conditions and management practices. From an economic perspective, for dairy cows, studies in Italy (van Kaam et al.) and France

(CNIEL) show that thermal stress reduces milk yields by around 1.5–2.5 kg per cow per day. Taking an average loss of 2 kg/day and applying the EU average raw milk price of EUR 53.23 per 100 kg³⁶, this translates into an income loss of approximately EUR 1.06 per cow per day. Temperature increases and heatwaves tend to affect southern and eastern EU MS more severely, though the number of heat-stress days varies by country. Considering the roughly 7 million dairy cows in Italy, Spain, Portugal, Greece, Malta, Cyprus, Croatia, France and Romania³⁷, the estimated loss amounts to about EUR 7.5 million per day under heat-stress conditions—a figure likely to be even higher once the loss of premiums or quality-related payments is taken into account.

The use of **sorghum as feed for livestock** is becoming popular, along with alfalfa. Currently, it is planted on less than 1% of UAA in the EU with a steady uptake (34% increase from 2023 to 2024). The data from the Polish case study indicated a cultivation cost of EUR 300 per hectare/year for sorghum. From an economic perspective, the **direct benefits** of adopting improved feed management practices help farmers mitigate the impact of rising silage prices during drought periods and can significantly reduce input costs on water and fertiliser. For instance, reduced maize yields due to drought in Southern and Eastern Europe are projected to increase silage prices by 10–15% by Q4 2025 (JRC MARS bulletin 2025). The Polish case study shows that, compared to maize, the production of sorghum costs approximately EUR 1 700 lower per hectare. Moreover, under limited rainfall conditions, sorghum can produce 72.3% more fresh biomass and 43% more dry matter than maize. It is essential to note that impacts vary from year to year, and the profitability of the practice depends on the baseline.

Choice of rootstock is a valuable tool in managing disease and pests in perennial crops, as well as resilience against heat or water stress in permanent crops; however, it is still under research and not available for all crops. It is widely implemented in viticulture. The data collected from the Spanish case study reveals that new rootstock seedlings can cost two to three times higher than conventional seedlings. The benefits of this technique are difficult to assess, as they need to be studied over a long period and replicated across different pedoclimatic conditions to improve our understanding of the behaviour of rootstocks combined with other varieties. Past data on losses from drought and heatwaves range from EUR 4 500 per ha for a specialist fruit farm in Spain (Spanish case study) to EUR 600 per ha for vineyards in France (Delahais and Robinet, 2023). However, it is difficult to estimate reliably how much of these losses could be avoided by changing rootstocks.

³⁶ EU prices of cow's raw milk. EUROSTAT (2025).

https://agriculture.ec.europa.eu/system/files/2024-01/eu-raw-milk-prices_en.pdf

³⁷ Number of dairy cows. EUROSTAT (2024). https://agriculture.ec.europa.eu/system/files/2024-01/eu-raw-milk-prices_en.pdf

Table 15. Assessment of farming practices (Choice and selection of species, breeds, varieties)

Farming practice	Investment cost	Operating and other costs	Benefits	Effectiveness against climate impact	Assessment
Select breeds / species based on thermotolerance	None	Cost of semen for dairy cows: €150- €200 per head for 2-3 doses. Labour required for insemination remains the same.	Increased fertility and lower mortality.	Highly effective against heat stress.	Depends (on farm objective in terms of yields)
Drought tolerant forage species - sorghum	None	€300/ ha compared to €2 000/ha for maize	Cost savings due to lower water and fertilizer demands.	Highly effective against drought	Depends (lower yields than maize in years without drought.)
Use of new species/varieties or drought resistant rootstock	Generally, does not require new investment, but guidance and training may be needed	2x the cost of normal rootstock	Cost savings on pesticides	Moderate against drought, heatwave, pest/disease	Generally positive (relies on a good preliminary assessment)

Source: study team

Diversification, desynchronisation and external risk management

Diversifying the production system can reduce farms' vulnerability to CC. This includes crop diversification or the use of variety in feedstock for a forage system. Cover crops or catch crops can be used to improve soil quality as well as to build up fodder reserves during periods of shortage.

Crop rotation is a widely used practice. Eurostat data shows that the uptake of crop rotation has increased from 59% to 71% between 2016 and 2023³⁸. We assess here the implementation of a different rotation cycle without changing the crops. This does not involve any investment costs. The new rotation system may result in increased labour costs (e.g. if the frequency of rotation increases), but the benefits from improved yields and reduced input costs tend to outweigh these costs.

³⁸ Eurostat, the percentage is calculated for the MS where data are available for 2016 and 2023, which represent 85% of total EU arable land.

Crop diversification, on the contrary, has relatively low uptake in the EU, representing only 3% of the total UAA, with a 12% increase between 2016 and 2020³⁹. Crop diversification can entail significant investment costs, depending on the crop introduced. Recurrent costs are also typically higher, including labour and input costs (e.g., for certified seed material). Economic benefits, both in terms of avoided damages and potential co-benefits, are high but more uncertain, in particular in the short term. However, it has been noted that crop diversity attracts wildlife and preserves soil fertility

Cover or catch crops are not widely popular, with limited uptake, despite a slight increase between 2016 and 2023 (from 8% to 11% of EU arable land). It has low investment costs, but high operational costs for inputs and labour, estimated at around EUR 300/ha to EUR 400/ha. It should be noted also that this practice is often combined with no or minimum tillage⁴⁰.

Box 1: Detailed analysis of catch/ cover crops

Cover crops refer to planting herbaceous species during periods when the main crop is absent, primarily for agronomic and environmental benefits, as opposed to so-called cash crops', which are primarily grown to be sold.

There is **no one-off investment cost**. Some low establishment costs can occur, mainly resulting from technical advice and designing the cover crop mixture. Recurrent costs, however, can be significant, especially when the mixture includes high-protein seeds

The cost assessment is done for field crops, based on the following assumptions:

- The baseline is no soil cover between main crops.
- Seeds are purchased, and not farm-saved. The cost is estimated at around EUR 60/ha based on available information.
- As a proxy, the additional time for seeding is estimated at 0.5 day/ha (or four hours/ha), and the labour cost is estimated at EUR 18/hour⁴¹.

Type of cost	Description	Unit	Costs per unit (in EUR)	Quantity (per ha)	Frequency	Total cost (EUR/ha)
Recurrent cost						
Inputs	Plant material	EUR/ha	250	1	Once a year	250
Labour costs	Seeding and cutting	Hour/ha	18	4	Once a year	72
Total						322

The **direct benefits** in terms of avoided losses cannot be quantified here, as cover or catch crops aim to improve the farm's overall resilience rather than limit losses from extreme events. However, the practices are assessed to be effective in reducing soil erosion and reducing the impacts of droughts by retaining water.

³⁹ Eurostat, the percentage is calculated for the MS where data are available for 2016 and 2023, which represent 85% of total EU arable land.

[https://ec.europa.eu/eurostat/databrowser/view/ef_fsi_cddiv\\$defaultview/default/table?lang=en](https://ec.europa.eu/eurostat/databrowser/view/ef_fsi_cddiv$defaultview/default/table?lang=en)

⁴⁰ Eurostat. Percentages are calculated over total arable land, and represent 85% of the EU arable land.

⁴¹ The reference used in these analyses for one day of labour cost is the hourly earnings for skilled agricultural workers 2018 * early earnings for Total occupation 2022 /early earnings for Total occupation 2018 * 1,25 (total labour costs) = EUR 18/hour

NPV Calculation

Cash-flow assumptions per ha:

Year 0-10: recurrent cost = EUR 322 (Cost of inputs and labour)

Years 0-3: revenue = EUR 306

Years 4-10: revenue = EUR 338 (improved yield)

Discount rate: 2.5%

Time horizon: 10 years

Total NPV: EUR 62/ ha

In general, the costs are estimated to be at least offset by the agronomic benefits, and in some cases by the sale or in-farm use of cover crops as fodder

Long periods of deficient rainfall and drought in the summer months can dramatically reduce pasture production. Management changes, such as **rotating livestock** to new pastures to improve grass recovery, **adjusting the grazing calendar**, and **diversifying fodder**, enable farmers to better cope with changing climatic conditions. The main direct costs relate to planning, monitoring, and, if necessary, investment in building or improving fencing and installing watering systems, as well as recurring labour costs for moving livestock. This can account for an investment of EUR 6 000- EUR 7 000 for fencing four hectares of paddock, including drinking stations and a recurrent cost of EUR 1 500 per year for maintenance of fence and time needed to move the paddock. Diversification of fodder through hedgerows, cover crops, etc., entails costs for seeds, inputs, and labour, but these costs are poorly documented, making them difficult to estimate. The **direct benefits** of these practices include extending the grazing period and reducing feed costs for farmers. During drought, when silage costs rise, adapting grazing helps to mitigate additional expenses. For example, under rotational grazing, 20% more grass is grown, providing farmers with additional grazing time. It has been estimated that there is a potential daily saving of EUR 1.71 for cattle being at grass rather than being housed⁴².

Table 16. Assessment of farming practices (Diversification, desynchronisation and external risk management)

Farming Practice	Investment cost	Operational and other costs	Benefits	Effectiveness against climate impacts	Asses-sment
Crop rotation	No or marginal initial costs	Labour and input costs generally do not change or decrease. - 100 €/ha to 0	Increases both the yield and quality of production	Moderate against drought and plant health	Definitely positive (optimisation of existing system)

⁴² TEAGASC. Agriculture and Food Development Authority, Ireland. <https://teagasc.ie/wp-content/uploads/media/website/animals/beef/A-guide-to-charges-for-Wintering-Arrangements-2020.pdf>

Farming Practice	Investment cost	Operational and other costs	Benefits	Effectiveness against climate impacts	Asses-sment
Crop diversification	Possibly new equipment, new plant material, software upgrade, and time spent on planning (up to k€50) €10 to €700/ha	Increased costs for seed material, labour costs, maintenance costs, etc. €60 to €150/ha	Possible additional income from new crop, increased yield	Potentially high against drought and plant health	Depends (can be highly positive but depends on the choice of new crops)
Cover crops / catch crops	None	Cost of seeds and cutting the crops. (€30 - €450/ha, more often around 300 €/ha)	Increased yields and improved quality, Possible additional income from selling cover crops	Moderately effective against the risk of drought and excess water, highly effective against soil erosion	Neutral to slightly positive (costs are offset by agronomic benefits)
Rotational grazing	€6 600 for fencing 4ha of paddock, including drinking stations.	€1 500/year 2-3 days per year for maintenance of fence + time spent in moving the herd	Cost savings since less feed is required. Improves soil health and soil organic matter	Moderately Effective against the impacts of drought	Definitely positive (provides cost savings with low investment and recurrent cost)
Adapted grazing calendar	None	None	Aligns stocking with seasonal grass availability; extends grazing period	Moderately effective against the impacts of drought	Generally positive (low-cost with efficiency benefits)
Diversification of fodder (incl legumes, hedgerows, additional cover crops etc)	None	Possible cost of seeds, labour, input (cost unknown)	Reduces fodder purchase dependency when silage costs are high.	Moderately effective against drought.	Neutral to positive (multi-benefit, resilience-building)

Source: Study team

Bolstering the resilience of plants

Nutrient-enhancing techniques such as mulching and adding compost are used to support plant resilience and optimise nutrient intake under changing climatic conditions. Practices such as intercropping also aim to improve agroecosystem function.

Natural mulching is most suitable for specialist crops, as the material for mulching can be difficult to procure for large areas. It does not include any investment costs, but it has high material and labour costs for scattering. The

cost for mulching for shredding and/or scattering can range from EUR 200 to EUR 450 per hectare. The benefits are mainly in terms of avoided damage, which can vary by production type, MS, exposure, and the intensity of CC impact. For instance, in 2021, the frosts caused EUR 3 billion in damage to the agricultural sector (FI-Compass, 2025). However, it is difficult to isolate the damage that could have been avoided with natural mulching. Other benefits include production gains, such as maintaining soil temperature and reducing damage from both frost and heatwaves to crops such as fruits and vegetables and vineyards.

According to CAMBIA report, the use of organic matter, including **compost**, generally requires little to no investment and does not increase operating costs significantly (EUR 50 per m³). The main cost depends on the type of crops, from EUR 40 per hectare for fruits to EUR 450 per hectare for maize. However, these measures have a limited impact in terms of avoided damages from extreme events, but they contribute to improving soil quality and the resilience of farms in the long term.

Table 17. Assessment of farming practices (Bolstering the resilience of plants)

Farming Practice	Investment cost	Operational and other costs	Benefits	Effectiveness against climate impacts	Assesment
Natural mulching	None	Cost of shredding and/or scattering (200-450 €/ha)	Faster ripening and higher productivity	Moderately effective against the risk of drought and erosion	Depends (can be difficult to implement on large areas)
Compost	None (assuming compost is purchased)	Main cost depends on the type of crops (from 40 €/ha for fruits to 450 €/ha for corn).	Agronomic benefits, which lead to higher quality and yields in the long term	Low effectiveness.	Neutral to slightly positive (Benefits improve in the long term, while costs tend to reduce)

Source: Study team

Protecting livestock, crops and harvests from extreme weather

Changes in the frequency and intensity of extreme weather events require farmers to implement a range of measures to protect livestock and crops. In periods of stress, animal welfare and health are maintained through herd management, microclimate management, nutritional adjustments, and protective infrastructure. This involves a mix of farming practices and strategies with very different cost implications.

Herd management by adjusting calving periods and changing stocking densities⁴³ reduces the need for feed without high upfront investments. This can be done by the reduction of unproductive livestock or by lowering the calving age from 3 to 2 years, or by selecting for earlier-maturing animals. Earlier finishing has no impact on production but reduces fodder requirements, along with greenhouse gas emissions, without the risk of carbon leakage (ABCIS). However, it is important to note that system complexity varies across pedo-climatic zones and terrain. For example, in mountainous areas with much permanent grassland, the only possible adaptation for feed scarcity is cattle reduction, whereas in lowland areas, it is easier to switch to crop rotation, diversifying fodder, etc.

By contrast, practices such as **improved natural ventilation** and **shade in livestock buildings** involve infrastructure modifications that require substantial capital investment. The cost for installing windows can range from EUR 2 000 to EUR 3 000 per window. Similarly, the cost of net and rolling system for shading system in barns can vary from EUR 80/m² to EUR 120/m². **Installing additional water troughs** in the pasture can cost around EUR 1 000 per trough. Nutritional adjustments, such as the **introduction of electrolytes**, help livestock cope with heat stress. The main cost is purchasing the electrolyte mix, which can be substantial depending on the number and weight of the animals. The cost varies between EUR 8 and EUR 11 per kg of electrolyte. For a calf, this corresponds to a cost of EUR 2/day, whereas for lamb, goat, sheep and chicken, the cost can vary between EUR 0.3/day to EUR 0.07/day.

Multifunctional nets are highly effective at reducing risks from rain, hail, and pests, but their high investment cost (EUR 30 000- EUR 45 000 per ha for structure and EUR 25 000- EUR 35 000 per ha for nets) makes them suitable mainly for high-value crops. There is no systematic data on the uptake of multifunctional nets in the EU. An interview with a researcher for the University of Parma (Italy) confirmed that multifunctional nets are widely considered the preferred method of crop protection in the fruit and vegetable sector in Emilia-Romagna. According to CAMBIA, the method is highly effective, preventing 100% of hail and heavy rainfall damage, compared to a farm with no crop protection. The current annual average damage from hail and frost for permanent crops can be estimated at nearly EUR 400 per hectare whereas damage from heavy precipitation can cost up to EUR 32 000 per hectare for fruit orchards, vineyards and olive groves, but the actual damages for individual farms are much higher (EIB Fi-compass study). It also leads to cost savings by reducing harvesting and sorting costs, which can represent up to 50% of total production costs. Indirect benefits include improved crop defence, higher

⁴³ In the poultry sector, changing stocking density may imply a change of economic model. The analysis provided here corresponds to the general situation when the practice only represents an adjustment of the existing farm system.

produce quality, and access to higher prices, all of which positively affect farm income.

Kaolin is an effective way to protect vines from sunburn, but the extent of its uptake at the EU level is unknown. Application of kaolin does not require any investment; only input and labour costs amount to EUR 200-EUR 300 per hectare. The direct benefits of kaolin include increased yield and improved product quality. In a study on the effects of kaolin application on pinot noir grapevines, it was noted that 30-35% of untreated wines were affected by severe water stress and produced unmarketable fruit. In comparison to the untreated vines, those sprayed with kaolin reported higher yield (+27%), higher anthocyanins (+35%) and higher concentration of organic acids (+11%) (Frioni et al., 2019).

Table 18. Assessment of farming practices (Protecting livestock, crops and harvests from extreme weather)

Farming practice	Investment cost	Operating and other costs	Benefits	Effectiveness against climate impact	Assessment
Adjust calving periods	None	None	Increased fertility.	Moderately effective against heat stress.	Generally positive (low-cost with benefits over long term)
Adjust animal stocking density	None	Reduced output affects farm profitability	Savings by reduction in feed.	Moderately effective against heat stress.	Depends (low cost but depends on the type of livestock)
Adding electrolytes in feed	None	Cost of electrolyte: (€1.71/ day per dairy cow, €0.3/ day per pig and €0.007/ day per chicken*). Very minimal labour is expected.	Increased yield.	Moderately effective against heat stress.	Neutral to positive (effective during heat stress, but recurring cost)
Improved natural ventilation	Cost of installing windows in the building: €2 000 - €3 000 per window	None	Increased yield, higher fertility and low risk of disease and lower mortality.	Highly effective against heat stress.	Definitely positive (high cost but long-term)
Sufficient drinking troughs	€1 000 per drinking trough	None	Increased yield.	Moderately effective against heat stress	Generally positive (low-cost, high impact)

Farming practice	Investment cost	Operating and other costs	Benefits	Effectiveness against climate impact	Assessment
Providing shade in livestock areas	Cost of net and rolling system: €80/m ² - €120/m ² depending on manual or motorized.	None	Increased yield, higher fertility and low risk of disease and lower mortality.	Highly effective against heat stress	Definitely positive (capital intensive but cost-effective per head)
Multifunctional nets	€30 000 - €45 000 /ha for structure €25 000 - €35 000 /ha for nets	7-8 days/ ha /year to open and close the nets	Avoided loss of produce, positive impact on soil quality.	Highly effective against rain, hail and pests.	Neutral (costs are offset by agronomic benefits)
Kaolin	None	€200 -€300 /ha (including labour)	Increased yield and quality of production.	Highly effective against damage from extreme temperatures	Definitely positive (very low costs compared to benefits)

Source: Study team

Stockpiling, increasing equipment capacity, and autonomy

Farmers increase resilience of their farm by improving self-sufficiency and buffering capacity. These include increasing on-farm storage capacity to enable strategic stockpiling of feed. According to the analysis conducted, there are no associated costs except maybe labour needed for storage activities.

Table 19. Assessment of farming practices (Stockpiling, increasing equipment capacity, and autonomy)

Farming Practice	Investment cost	Operational and other costs	Benefits	Effectiveness against climate impacts	Assessment
Safety stocks of fodder	None	None	Reduces the cost of buying fodder when silage costs are high.	Highly effective against drought.	Generally positive (low cost, depends on storage capacity)
Solar drying of fodder	None	Possible labour cost	Lower energy consumption and reduces the need for buying commercial fodder.	Moderately effective against drought	Depends (only suitable in areas with enough sunny days)

Source: Study team

Sustainable water management

Water management practices such as rainwater harvesting and drip irrigation, supported by a DSS (Decision Support System), can lead to water saving

during periods of drought and reduce the dependence of agriculture on groundwater.

There is no clear data available for the uptake of **rainwater harvesting** in agriculture. The cost reported for rainwater harvesting in the Spanish case study primarily covers the installation of the water-collection and storage infrastructure. The initial installation, depending on the size of the farm and the volume of water to be stored, can range between EUR 1 500 and EUR 20 000. According to the feedback from the French case study, where a rainwater collection system was installed on top of greenhouses, the cost savings were reported to be limited due to the relatively low cost of water abstraction, except during droughts, when costs increase. However, it was noted that it has significant environmental benefits; collecting rainwater limits the pressure on the aquifer from drilling and reduces the farm's vulnerability to water scarcity during drought.

The CAMBIA report provides a qualitative analysis of **drip irrigation** in Italy, where it has been reported to have high uptake in horticulture and viticulture sectors. The investment cost for installing a drip system is estimated to be high. The feedback from the Italian case study reports an investment cost of EUR 1 600 per hectare, including the cost for the control unit and soil moisture sensors (systems used by farms associated with Producer Organisations (POs)) range from EUR 100 to EUR 220 per hectare. This estimate refers to equipment suitable for monitoring a parcel of 5 to 7 hectares. The costs are offset by the high protection provided against drought. For a specialist fruit farm, the damage caused in an average drought year is calculated to be EUR 4 500 per ha (Spanish case study). Drip irrigation also leads to cost savings in water and energy of 30-40% compared to conventional irrigation. Other benefits include better produce, higher yields and lower plant and crop diseases.

Table 20. Assessment of farming practices (Sustainable water management)

Farming Practice	Investment cost	Operational and other costs	Benefits	Effectiveness against climate impacts	Assessment
Rainwater harvesting	€ 1 500 to € 20 000 for water tank + 2 labour days for setup	1 day per year for maintenance	Cost savings (-30%) and reduced dependence on groundwater during drought	Moderate against drought and water scarcity due to limited storage capacity	Generally positive (low cost with potential benefits)
Drip irrigation (equipped with Decision Support System (DSS))	€2 100 - €5 000 per ha for viticulture €1 600 - €2 600 per ha for horticulture	€200 - €300 per ha for viticulture €600 - €800 per ha for horticulture	Cost savings and reduced dependence on groundwater during drought	High against drought and water scarcity	Neutral (high cost offset by reduced cost of input and greater yield)

Source: Study team

Other green water focused practices and strategies related to sustainable water management (including flood risk reduction)

Soil management practices and structural landscape features such as agroforestry increase resilience to extreme events by reducing wind speed, protecting soil surfaces, improving soil water retention and offering natural protection against flood risk.

The uptake of **agroforestry** is at 9% of the EU-27 UAA (15.4 million ha) as per the latest data from 2020 (European Parliament). The low uptake can be partially attributed to the significant upfront investment required, including planning, materials, and considerable labour time. For hedgerows, the investment cost can be as high as EUR 1 150 per 100 meters and EUR 900 per hectare for silvoarable. For field crops, agroforestry can reduce productive land and can sometimes create competition for water resources. This can lead to indirect costs due to reduced yield. For livestock farms, a few years after planting, agroforestry can provide natural shade for ruminants, reduce heat stress, and protect animal welfare. Economic benefits for dairy cows under silvopasture can be assessed similarly to animal welfare practices. Farmers can also diversify their income by selling by-products such as fruit, nuts, wood fuel, or timber.

Box 2: Detailed analysis of agroforestry (hedgerows)

Costs include one-off investment along with suitable training/ guidance, and recurrent costs for maintenance and harvesting.

The cost analysis is based on the following assumptions:

- The baseline is farmland without hedgerows.
- The labour cost is estimated at EUR 144/day.
- 1 ha of permanent grassland = 160 lm of hedgerows; 1 ha of arable land = 56 lm of hedgerows⁴⁴

⁴⁴ https://cne-elevagesruminants.fr/wp-content/uploads/ficheargumentairelevage/FicheCne_Biodiversity.pdf

The **direct benefits** include avoided losses and economic benefits. For farms with livestock, hedgerows improve animal welfare by providing shelter during heatwaves. Economic benefits include additional income generated by the sale of tree products and wood for hedgerows. For cropland, agroforestry can help improve water retention.

For hedgerows, wood can be sold for different uses, including use as litter, woodchips, pallets, etc. The productivity is set at 0.1 ton per 100 lm of hedgerows. The data obtained

Type of cost	Description	Unit	Costs per unit (in EUR)	Quantity (per 100 lm)	Frequency (per year)	Total cost (EUR/ 100 lm)
One-off costs						
Design and planning	Planning required for passage of machinery	Labour days	144	0.03	Once	4
Investment	Plant sapling (40cm apart)	Piece	2	250	Once	500
	Protection and mulch	Piece	2	250	Once	500
Labour	Preparation of ground and planting	Labour days	144	1	Once	144
Total investment in EUR per 100 lm						1148
Recurrent cost						
Maintenance	Cutting and pruning	Labour days	144	0.1	Annually (once a year)	14
Equipment	Maintenance cutter	Day	50	0.02	Annually (once a year)	1
Total recurrent cost						~15

from the French case study provides the rate for the sale of wood as woodchips (after adjusting for PPP).

Product / Price Type	Price per Tonne	Price for 0.1 T
Price per tonne of green wood chips	€ 48	€ 4.81
Price per tonne of dry wood chips*	€ 9	€ 0.66
Price per tonne of labelled green wood chips	€ 56	€ 6
Price per tonne of labelled dry wood chips*	€ 111	€ 7.94

*1 T of fresh wood = 0.714 T of dry wood

NPV Calculation

Cash flow assumptions per 100m of hedgerows:

Year 0: initial investment= - EUR 1 148

Year 1: no cost

Year 2-10: Maintenance cost (only for harvesting) = - EUR 15.4

Revenue from the sale of woodchips = EUR 7.94 per 100m

Discount rate: 2.5%

Time horizon: 10 years

NPV: - EUR 1214 /ha

In general, costs are estimated to be higher than economic benefits in the first few after planting hedgerows. However, the significant environmental benefits is not taken into account.

Soil management plays a crucial role in regulating both the retention and drainage of water. **Conservation tillage methods** (e.g. minimum tillage, no-till, strip tillage) reduce disturbance while also limiting compaction. The costs for switching from conventional ploughing to minimum tillage depend on the need for the purchase of machinery (EUR 60- EUR 160 per hectare). According to CAMBIA, this cost, when new machinery is needed, which is not always required, can be offset to a large extent by the sale of old machinery. As a result, depreciation costs are estimated at around EUR 40 per hectare per year. The overall costs and benefits assessment is generally positive as a result of reduced labour and reduced fuel costs. However, it is important to note that yields are reduced in the first few years, it takes time for the benefits to be realised and is not suitable for all types of soil. The available data show a high level of uptake for minimum tillage between 2016 and 2023, based on Eurostat data (from 24% of the arable land in 2016 to 59% in 2023⁴⁵). Practices such as **strip tillage or vertical tillage** have similar benefits, but higher investment costs.

Table 21. Assessment of farming practices (Other green water focused practices)

Farming Practice	Investment cost*	Operational and other costs	Benefits	Effectiveness in avoiding climate impacts	Assessment
Sylvopasture/silvoarable	€950/ ha	€600 per year including labour cost for pruning and fertilising	Natural shade for livestock and additional income from tree produce.	Moderately effective against excess water, highly effective against soil erosion	Neutral (costs are offset by agronomic benefits)
Hedgerows	€585/ 100 lm	€200 per year for labour required to prune the hedgerows	Natural shade for livestock and reduced cost of animal litter and bedding.	Moderately effective against excess water, highly effective against soil erosion	Neutral (costs are offset by agronomic benefits)
Minimum tillage/Reduced tillage	Can require replacement of tillage equipment in some cases (around 40€/ha for depreciation costs)	Generally lower labour input costs (< 0.5 day/ha/yr) and lower fuel costs (est. at around – 15 €/ha).	Low impact on yield.	Effective against soil erosion and moderately effective against drought.	Generally positive (especially if no investment required)

⁴⁵ Eurostat. Percentages are calculated over (total arable land – arable land excluding tillage), and for the Member States where data is available in 2016 and 2023, which represent 85% of the EU arable land.

Farming Practice	Investment cost*	Operational and other costs	Benefits	Effectiveness in avoiding climate impacts	Assessment
Strip tillage / Vertical tillage	Significant investment costs, which can be partially offset by the sale of old equipment (60 – 160 €/ha)	Lower costs, similar to minimum tillage	Low impact on yield.	Effective against soil erosion and moderately effective against drought.	Neutral to slightly positive (generally applied in medium to large farms)

Source: Study team

2.4.2 Cost and benefits of adaptation at EU level

Estimating the cost of adaptation at the EU level faces numerous methodological limits. In addition to the uncertainties related to the costs and benefits of individual practices, providing EU level estimates implies choosing an appropriate baseline and deciding what to include in the adaptation costs. The choice of baseline affects which investments are included in the costs. For instance, investments that would be effective under stable climatic conditions may become significantly less efficient as climate impacts intensify. A second challenge is isolating adaptation-specific costs from other changes in agricultural systems (World Bank 2020). As highlighted in SQ3 and in the analysis of farm-level changes, farmers do not systematically adjust their practices in response to CC; many changes occur for other reasons such as efficiency improvements, market incentives, or social norms, which complicates the attribution of costs solely to climate adaptation.

The literature is limited on this topic, only one study was identified providing an overall assessment of climate adaptation, specifically for the agricultural sector, at macro level. A study, from i4ce (Institute for Climate Economics), in France, estimates that approximately EUR 1.5 billion per year may be needed over the next decade to deploy large-scale technical measures to maintain yields of the main French crops, assuming no structural changes to agricultural models. France covers approximately 18% of the total UAA in Europe and 15% of EU production. Extrapolating this figure for all of the EU would represent a cost of adaptation of EUR 10 billion per year. This is only a very rough estimate as the cost of adaptation would vary for each MS depending on a variety of factors, but it gives an order of magnitude.

On the other hand, the most comprehensive study to date on the impact of CC on EU farms, estimated the current average annual losses resulting from climate events at EUR 28.3 billion per year at EU level. The study relies on methodologies used in the insurance sector to assess costs at the current and projected future levels of risk, based on historical hazard data (40 years of pre-2024 losses), meteorological expertise, stochastic statistical techniques and

climate models. For this study, the costs at current levels of risk are used, but the literature shows that average EU crop losses, from droughts and heatwaves alone, tripled over the past 50 years (from -2.2% between 1964 and 1990 to -7.3% between 1991 and 2015 on average) and that overall agricultural losses from climate extreme events could increase by 42 to 60% by 2050 (Fi-compass, 2025).

2.5 SQ5: In view of water related CC challenges, how can – within the principles of integrated water management – the water resilience of agriculture to water related CC impacts be increased?

The resilience of agriculture to water related climate change impacts can be increased through a combination of reducing water demand, increasing efficiency, water reuse and extending water supply. This should follow the priority outlined in the EU Water Resilience Strategy, with a focus on reducing use, as the impacts of water scarcity and extreme flood events will only increase over time. That requires that policy implementation supports natural retention measures, including in agricultural soils and through green infrastructure such as wetlands. Such measures are currently underused, emphasising the need for change in terms of the advice and incentives available to farmers and effective implementation of the WFD to regulate water abstraction and manage resources sustainably.

The challenge of improving water resilience for the agriculture sector needs to account for future CC projections and be coherent with wider demand for water, for public use and other sectors such as energy and transport, but also for nature (European Commission, 2025b COM (2025)280). Any solution for agriculture should align with the Water-Energy-Food-Ecosystem (WEFE) Nexus (Magagna et al., 2019). This requires a systematic focus on water use across competing sectors, including governance and allocation at river basin level. The evidence from published literature and primary research in this study (i.e., case studies, interviews and focus groups) suggests that, while there is an established basis for governance of water resources at river basin level, the management of water resources is highly variable, often complex and is not always coherent with the principles of integrated water management (European Union, 2019). Across Europe, increasingly degraded soils are undermining the resilience of agricultural landscapes and amplifying water-related risks. Extensive evidence shows that soil erosion, declining soil organic matter, and widespread compaction have reduced infiltration rates and water-holding capacity in many regions (Panagos et al., 2015; Ball et al., 2015; FAO & ITPS, 2015). These trends are further exacerbated by CC, which is intensifying droughts and extreme rainfall events and exposing already-fragile soils to

greater hydrological stress (EEA, 2019; IPCC, 2019). The European Commission has highlighted that these forms of degradation are now widespread across EU Member States and are directly limiting the capacity of soils to buffer water scarcity and mitigate flooding (European Commission, 2021). Against this backdrop, improving water resilience in agriculture requires approaches that simultaneously address soil health, future climate pressures, and the competing demands placed on Europe's water resources.

Within this context, the water hierarchy (European Commission, 2025c) provides a critical framework for prioritising adaptation measures in agriculture and ensuring coherence with the Water Efficiency First principle. As outlined in the Commission Recommendation on Water Efficiency First (European Commission, 2025c) and supported by the European Water Resilience Strategy (European Commission, 2025b COM(2025)280), actions should follow a clear sequence: reducing water demand as the first and most effective intervention, followed by increasing efficiency in water use, then promoting the reuse of water, and only as a last resort, expanding water supply. Applying this hierarchy to agricultural adaptation aims at ensuring that solutions respond to both current pressures and long-term sustainability goals, while avoiding maladaptive practices that increase dependency on scarce resources. Thus, this chapter is structured to follow the water hierarchy.

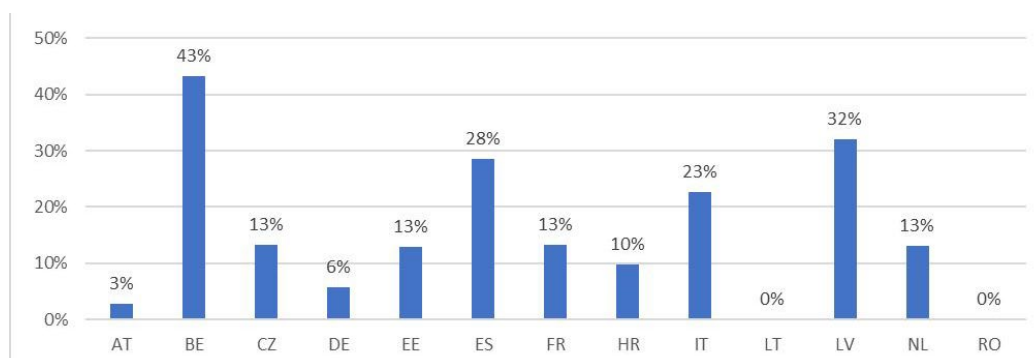
Reducing overall water use and reducing flood risks in agricultural systems is the fundamental objective of any adaptation policy, given the pressure on this resource, especially in southern Europe but across all MS to some degree. Evidence from this study and published literature highlights a number of broad approaches to achieve a systemic reduction in water use by agriculture, simultaneously capable of reducing erosion by runoff and reducing flood/water logging risks. These can all be supported through cross-cutting public investment in research and development, dissemination and support for uptake, as well as policy incentives and regulation. The scope for implementation of adaptation also needs to consider issues of acceptability and economics.

2.5.1 Extent to which overall structural resilience to water related challenges has increased as a result of adaptation

An assessment of the third river basin management plans (European Commission 2025a) reports a small improvement in the quantitative status of groundwaters in several Member States: 95% of groundwater bodies were reported in good status in 2016-2021 against 92.4% in 2009-2015. The extent of poor status was most significant in Spain, Hungary and Italy at over 20%. In 84% of the identified cases, groundwater bodies failed to achieve good quantitative status because more water is abstracted from the aquifer than its natural capacity to recharge. Data is available at MS level on water abstraction from groundwater and surface water in the EEA but is historic. Significantly, several MS expect the situation to worsen, as they predict that the number of

groundwater bodies at risk of not achieving good quantitative status by 2027 will increase, in some cases quite substantially (See Figure 11).

Figure 11. Percentage of groundwater bodies that MS report as at risk of not achieving good quantitative status by 2027 (only countries with e-reporting)



Source: EC report on implementation of the Water Framework Directive (2025)

The assessment of the 3rd RBMPs (2025) concludes that there is an increasingly compelling need to adopt changes in practices, including a much better uptake of water reuse in line with the EU Water Reuse Regulation (2020), and switch to crops more adapted to the region-specific hydrological conditions, as well as improved soil management.

A report on the contributions of water saving to a climate resilient Europe (Wolters et al., 2025) provides estimates of expected changes and impacts of operational management and technical water saving measures in agriculture on demand for irrigation water. For example, it estimates that:

- Where each country could achieve at least the same performance as the regional average of water intensity⁴⁶, the potential water saving by the agricultural sector could be around 12% at the EU level;
- The EU-27 could save about 6,070 million m³ of water annually through improvements in the conveyance system, reducing agricultural water abstraction by about 10%, with the largest potential gain in Southern Europe;
- Based on matching the best performing country in each region, in terms of national application efficiency, the EU-27 can save around 4,900 million m³ or 8% of abstracted water for agriculture annually, with the largest water savings in Southern Europe;
- There are considerable possible reductions in irrigation volume from using drought-resistant crops and cultivars (20-40% local saving potential under specific favourable conditions).

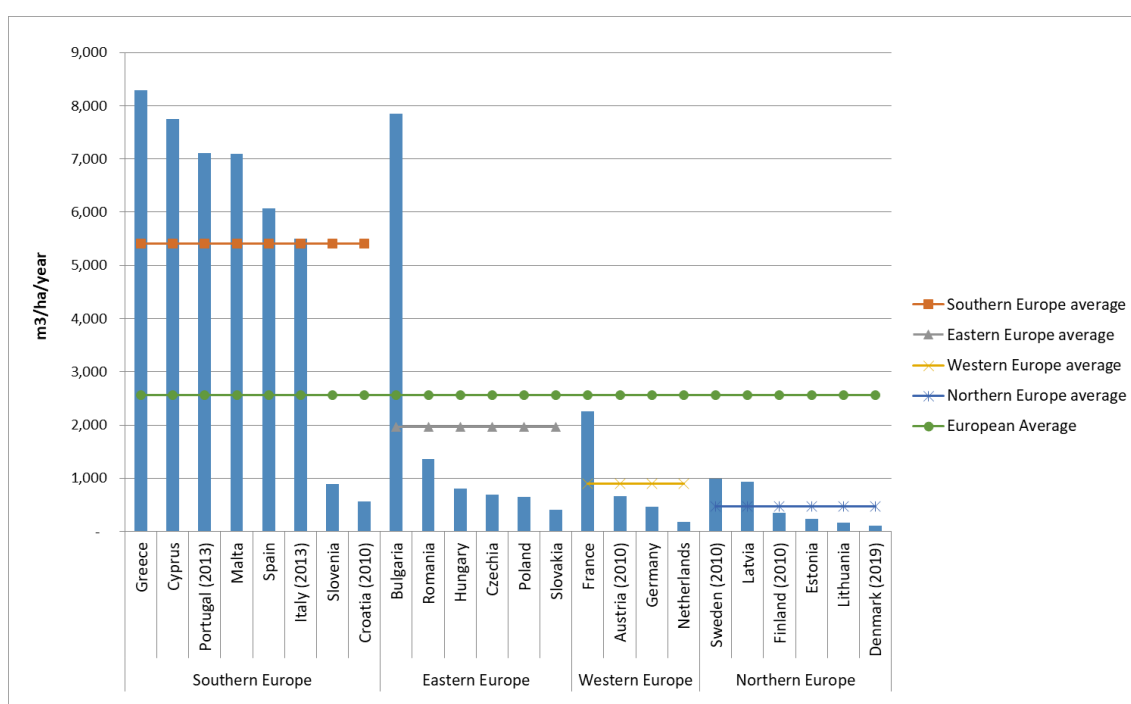
However, these theoretical savings and efficiencies are unlikely to be additive or to be practically achievable across the EU. Indeed, Wolters et al. conclude that

⁴⁶ Volume of water used per output

water savings in agriculture might be limited to 5%. However, these calculations do not account for precision farming or soil management to save and store water. As over 60% of European soils are estimated to be unhealthy and further degrading (European Commission, 2025c), the opportunity for reducing use is substantive.

There are no established indicators for adoption of water-saving practices to assess the extent or effectiveness of water-saving practices across farming systems. Partial data exists at national, regional, or project levels, and some proxy indicators (e.g., irrigated area, irrigation type, CAP-supported investment) can be used. While data on water use for agriculture over time across the EU27 is not readily available there is some data on absolute extent and reliance on abstraction (See Figure 12).

Figure 12. Irrigation abstraction per hectare of irrigated land in Europe by 2016



Source: EEA, 2021 (from ETC-BE Report 2025/1)

The analysis by Wolters et al. (2025) finds that water abstraction for agriculture on average accounts for 29% of total water abstraction and 50% of total water consumption in the EU, with an increasing trend in Southern Europe since 2010. These figures are consistent with EEA data, which also highlights that water use in agriculture has been increasing in southern Europe since 2010 (EEA, 2023b).

2.5.2 Adaptation measures to increase the water resilience of agriculture to water related CC impacts

The range of adaptations available to farmers for water-related CC impacts (presented in SQ1.3, see section 2.1.3) includes a variety of approaches, with an emphasis on increasing efficiency of irrigation systems. Risks of maladaptation identified in SQ2 highlight the potential for rebound effects associated with irrigation modernisation. Indeed, this often leads to an increase in water consumption rather than a decrease. Furthermore, such efficiency improvements are incremental by nature, and as such do not address the root causes of vulnerability to water-related impacts of CC. As such, they can mask the need for transformative change by major water users (e.g. through reducing demand) and reduce the water available to the wider system, including ecosystem services (rebound effect). In other words, efficiency measures related to water use can contribute to resilience if they are implemented alongside a constraint on total water consumption; while improving efficiency alone does not automatically reduce overall use, coupling efficiency upgrades with a cap on water extraction provides a clear incentive to invest in more efficient irrigation practices.

The case studies illustrate a different focus across the five regions studied but each illustrates examples of water retention. In Pays de la Loire, France, there has been a concentrated effort to plant trees and hedgerows to reduce the risk of flooding and water contamination, retain water within the landscape and to protect animals against extreme temperature. This is supported by the regional authority, the river basin authority and the CAP (Eco scheme). In Catalunya, Spain, the CAP Eco-scheme supports farmers in increasing the water retention capacity of soils by building organic matter through green cover crops, applying organic fertilisers, and minimising or avoiding tillage in vineyard and cereal crop cultivation. In Emilia-Romagna, Italy, a relatively new technique includes the combination of bio-fertilisers with natural soil amendment like biochar to enhance soil health, water holding capacity and infiltration, and resilience to drought. In Upper Austria, some farmers have built small-to-medium on-farm water storage ponds to retain water so that it is available in response to the change in the distribution of precipitation over the year (building these reservoirs requires a water abstraction permit and a construction permit if the pond interacts with groundwater or natural watercourses). These ponds are filled using rainwater, runoff, small streams or well water. In Wielkopolska, Poland more farmers are becoming convinced to use intercropping to manage water scarcity.

Evidence from interviews underscores that all four strategies (water demand reduction, increasing efficiency, water reuse and supply extension) are needed, but their relative weight must reflect local conditions. Water demand reduction through soil management and crop diversification was consistently highlighted as the priority, supported by both interviews and literature. Extending supply

(such as through dam construction) seems to be essential in certain contexts, but risks maladaptation if it drives intensification and diverts water from deprived areas and ecosystems elsewhere. Local retention measures show that smaller, decentralised storage can also provide systemic resilience if it is implemented at scale. Extending supply through desalination is viable in some contexts but must be weighed against energy and ecological costs and for those reasons may be considered as last resort. In other words, there would be 'no regrets' options to consider first.⁴⁷

Additionally, evidence from a focus group with experts highlighted the intrinsic connection between water quality and water quantity, stressing that both dimensions are fundamental to building long-term resilience. Addressing these aspects in isolation risks overlooking key interdependencies that shape overall water security in face of CC impacts.

2.5.2.1 Reducing water demand

As outlined in SQ1, research highlights the role of soil management (e.g. through reduced tillage, cover crops, managing soil structure) and green infrastructure (e.g. buffer strips, hedges, wetlands) to retain more water in the local environment as a key aspect of adaptation to both water scarcity and flooding. Such approaches also have co-benefits: improved crop productivity, improved biodiversity, animal welfare, avoidance of soil erosion and nutrient loss, the latter supporting improved water quality and avoidance of silting rivers systems and reservoirs.

Limiting water demand was repeatedly identified in interviews as the first priority. Farmers and experts pointed to soil fertility, crop choices, and precision irrigation as levers to reduce water consumption without undermining yields. Findings from interviews indicate that producers in Spain and Portugal highlighted the value of soil management practices such as cover crops, mulching and organic amendments to increase water retention, reduce evapotranspiration and build resilience against dry periods. Humus-rich soils with active biota can absorb heavy rainfall more effectively, recharge groundwater, and retain moisture during dry periods.

Fruit and vegetable producer organisations (POs) also reported that sensor-driven irrigation systems had reduced water use by around 20% compared with 15 years ago, while trials with new citrus and papaya varieties aim to further lower water requirements. Yet these examples also illustrate the complexity of demand reduction. Interviewees recalled that reducing tree canopies to limit transpiration ultimately damaged yields, showing trade-offs between bigger canopies (and theoretical yields) and avoidance of soil moisture deficits that

⁴⁷ 'No regret' options address risks of climate change but entail no hard trade-offs with other objectives

(presumably in drought years) limit yields and perhaps reduce quality of all produce. Precision agriculture should be seen as a useful tool but not a substitute for systemic change. Sensors, soil probes, and variable-rate technologies can help optimise timing and reduce inputs, but resilience depends fundamentally on crop rotations, soil health, and diversified systems.

Interviews with civil society organisations offered a strong case for a systemic focus on soil and landscape management, advocating for restoring the ‘small water cycle’ by retaining rainfall locally through micro-structures such as log dams and terraces, combined with building humus in soils. This can sustain crops through drought but also improve infiltration, support aquifer recharge, reduce floods and even stabilise regional rainfall through evapotranspiration feedback. The interviewees stressed that this approach, however, requires long-term incentives and education while current EU agricultural subsidies do not effectively support water-retaining practices. Together, these perspectives indicate that limiting demand relies not only on technology but also on agronomic choices, regenerative farming systems, and financial support that reward ecological performance.

There is a clear justification for public support, including through CAP and river basin initiatives on nature-based solutions (NbS). Diversification, desynchronisation and external risk management together with selection of water and/or heat tolerant species, breeds, varieties is also an important strategy that can be pursued by farmers in tandem with the public sector investing in research and development to inform best practice strategies and decision-making tools.

2.5.2.2 Increasing efficiency

Improving water use efficiency can include reduction of water losses and leaks from storage or distribution infrastructure but mainly focuses on improved methods for irrigation of crops. Modernising existing infrastructure and ensuring governance safeguards were seen as priorities by interviewees. A recurring issue is ageing irrigation networks; one interviewee estimated that up to 40% of water is lost through leaking pipes, underlining that modernisation of conveyance systems should precede any extension of water supply.

However, in practice it is common to find a systematic process of production intensification, with demands for water much higher than initially expected, rapidly exhausting the sustainable supply capacity of the basins. This rebound effect is associated often with growers seeking to justify their investment by extending the area irrigated and/or introducing new crops with greater added value but also with greater water requirements. Further, moving from surface irrigation to drip or sprinkler irrigation is also more efficient so that less water is returned to the river basin. On this basis, public support for irrigation in areas of

water scarcity can only be justified on condition of a calculated reduction in total water extraction, although it should be noted that water abstraction is often not metered and can be difficult to regulate.

2.5.2.3 Water reuse

Water reuse has been identified by the European Commission as a relevant solution to be further promoted in the EU to address water scarcity. This generally refers to reusing treated wastewater from major Wastewater Treatment Plants (WWTPs) and the practice is already used to some extent. Minimum quality requirements and preventive measures are needed to promote the safe reuse of treated urban wastewater in agriculture. There are issues of cost and a JRC study (Pistocchi et al., 2018) noted that reuse is most suitable where irrigation infrastructure already exists and the necessary additional investments are minor. Another JRC paper (Alcade Sanz, L and Gawlik, B., 2017) states that additional water supply infrastructures should be considered as an option when other options have been exhausted, including effective water pricing policy and cost-effective alternatives. Stakeholders consulted noted that reuse of wastewater does not always reduce pressure on water resources, as it typically draws on water already circulating within the hydrological cycle and may be more appropriate in coastal areas, where water would otherwise flow into the sea and be lost from continental systems. While wastewater reuse can be beneficial in downstream or coastal contexts, caution is required upstream, where it may reduce normal downstream flows and affect water availability for other users and ecosystems.

Water reuse through water storage techniques can be used at farm or river basin level as a means of managing the seasonality of water availability but does not contribute to reducing overall demand or extending total supply. It relies on water retention or construction of reservoirs and ponds to store water in times of excess for use in times of scarcity. A number of approaches are relevant⁴⁸:

- On-farm water retention features (e.g., bunds, tanks, buffer strips), runoff attenuation features (e.g., woody debris dams, willow barriers) and the use of green infrastructure (e.g. floodplains) for temporary storage;
- Mid- and small-sized ponds and wetlands.

Investment to store water can similarly lead to expansion of the irrigated area and diversification to more water-demanding crops (Wolters et al. 2025). However, at a river basin scale, increasingly severe water scarcity requires that overall water use from agriculture is reduced. Current incentives e.g. through

⁴⁸ Sustainable storage of water should preferably be in soil and groundwater or NbS investments with storage in grey investment justified (in compliance with WFD Art 4(7)) to overcome seasonal shortage with no structural decrease of rains/flow risks.

CAP and other policy instruments for infrastructure investment can allow some farmers to maintain existing cropping systems (through efficiency gains) or increase use (through storage) while less is available for other uses, including local ecosystems. Managed and equitable allocation of this scarce resource can be best managed through strategic investment and water pricing and/or regulation at river basin scale. Interview evidence demonstrates that water reuse can be understood as the third essential pillar of building resilience. The strategies described by the interviews ranged from on-farm micro-retention to large-scale reservoirs, with a number of ecological and social trade-offs.

Interviewees stressed the importance of the 'slow water' principle at landscape level. After decades of drainage and channelisation aimed at moving water off land quickly, adaptation requires slowing it down through restoring streams, reducing flow velocities, and introducing retention structures. On one hand, small on-farm ponds, wetlands and log dams were mentioned for their dual role in reducing runoff and securing water for dry periods. On the other hand, it was noted that strategic reservoirs and dams can transform agricultural potential if carefully managed. For example, evidence from the interviews indicate that a large dam in southern Portugal, now irrigating nearly 200 000 hectares, has enabled the shift from low-yield traditional olive groves to intensive, mechanised systems that double productivity. Farmers use meteorological stations, satellite imagery and soil probes to ensure irrigation stays within allocated quotas. Nevertheless, only about 10% of fields in the region are irrigated, and high summer temperatures still force work slowdowns. Such infrastructure requires ecological safeguards, as over-intensification risks degrading soils, ecosystems and long-term water balances. Regional authorities can play an instrumental role here, focusing on legal and institutional mechanisms to support retention. For example, another interviewee stated that a region in Germany recently simplified permitting for water reservoirs, requiring only notification rather than full applications, in order to accelerate investments that both mitigate floods and recharge groundwater reserves.

These diverse insights highlight that water reuse strategies are most effective when multi-scalar: integrating field-scale retention, catchment-level rewetting and agroforestry, and strategic reservoirs under strict ecological safeguards. Storage measures should not only compensate scarcity but actively rebuild water cycles and generate co-benefits for biodiversity and climate regulation.

2.5.2.4 Extending water supply

Desalination remains an option to extend water supply in coastal areas, beyond green, blue and grey water, but is associated mostly with maladaptation, insofar as it is (fossil) energy intensive. Nevertheless, when water scarcity is chronic this offers a solution where public water supply is at risk and agriculture can

(co)benefit from the investment and infrastructure.⁴⁹ Where the private sector has a significant need that can be justified economically, for example high value fruit and vegetables, it can make a separate case for investment. There is some resistance from farmers to the use of water from desalination plants (Aznar-Sánchez, et al., 2017) and issues of salt contamination that need to be regulated and well managed to minimise unintended side-effects. Similar concerns apply to water reuse from urban wastewater treatment plants (UWWTPs), as seen in some MS, where salinity and contamination issues have posed significant challenges. This was highlighted by the public authorities interviewed.

Extending supply was described by interviewees as a necessary but conditional strategy, appropriate only when demand reduction, improved efficiency and storage are maximised. Desalination was mentioned as a tool with niche applications. For example, in Spain desalination supports high-value fruit and vegetable exports, but its high energy cost makes it unsuitable for widespread use. Such technologies must be assessed within river basin management plans to avoid maladaptation.

From a governance perspective, integrated water management requires incentives and rules that reward ecological performance. The experts interviewed discussed 'true-cost' approaches that internalise externalities such as water pollution and soil degradation, aligning private farm-level decisions with societal goals. Implementing strategies that address both short-term protection and build resilience are needed. That involves choices in the allocation of funding and support that will require good evidence, innovation and change, and strong governance at all levels. Such a multi-level strategy that encompasses an appropriate balance of most suitable CCA to meet local priorities across all sectors should include:

Such a multi-level strategy that encompasses an appropriate balance of most suitable CCA to meet local priorities across all sectors should include:

- Developing water use indicators and utilising robust water use statistics at EU, national and river basin level to improve the allocation and management of water resources;
- Establishing participatory governance mechanisms at the catchment and river basin levels to ensure that all relevant stakeholders, including water users, farmers and their communities, public authorities, and environmental organisations, are actively involved in decision-making and the co-design of water management measures;

⁴⁹ While desalination can increase overall water availability, its high costs, reliance on fossil energy, and associated environmental impacts mean it should be deployed cautiously and only where chronic scarcity leaves no feasible alternatives.

- Establishing and enforcing river-basin water-allocation frameworks that combine legal limits, social acceptance, and mutual user control to prevent rebound effects and ensure equitable abstraction;
- Using economic instruments such as water pricing based on volume and incentives for achieving higher Water Use Efficiency (WUE), while avoiding concentration of water rights and recognising that water markets must be carefully regulated and context-sensitive to prevent inequities observed in other international experiences;
- Promoting a water-saving culture among all stakeholders, coupled with the development of participatory education and awareness initiatives and supporting research and development of tools and technologies that enable inclusive and sustainable water management;
- Promoting good practice within and across public and private organisations that have a role to play in water use and management, with a strong emphasis on knowledge exchange, capacity building, and stakeholder collaboration.

2.6 SQ6: What is the role of the CAP and other policy instruments in supporting/accelerating farmers adaptation to CC and increasing water resilience?

A diversity of CAP instruments (conditionality, eco-schemes, agro-environmental and climate commitments, investments linked to SO4, SO5 and SO6, cooperation, sectoral interventions) support adaptation of agriculture and water resilience. Other policy instruments (Horizon, LIFE, RRF, EIB, WFD) support directly or indirectly adaptation in EU agriculture. They present varying degrees of coordination or integration with the CAP to address climate impact drivers in the different EU biogeographical regions. Many tools are available to support individual farming practices, but fewer tools exist to address water-resilience beyond farm level, at landscape level, through appropriate local strategies.

2.6.1 SQ6.1. Which CAP instruments with relevance to climate and water resilience have been implemented at national, regional, local and sectoral level?

This section presents the methodological approach and the findings on the CAP instruments with relevance to climate and water resilience at national, regional, local and sectoral level. It starts by presenting the sources and methods mobilised to make the assessment, followed by a synthesis of findings per instrument. In addition, a detailed analysis of farming practices implemented under eco-schemes, AECC and green investments is provided based on the

JRC's classification of farming practices⁵⁰, with a focus on major producers located in the Mediterranean bio-geographic region.

Sources and methods mobilised

To assess CAP instruments with relevance to CCA and water resilience that have been implemented at national, regional, local and sectoral level⁵¹, a diversity of sources and methods were used and triangulated, as shown in Table 22.

Table 22. Overview of sources and methods mobilised for SQ6.1

CAP Instrument	Analysis based on:
SMR	Literature review, case studies and interviews
GAECs	Literature review, analysis of farming practices developed by the JRC, case studies and interviews
Eco-schemes, AECC and green investments	Literature review, analysis of interventions through farming practices developed by the JRC, agrifood data portal, SFC data
Sectoral interventions	Literature review, case studies, interviews
Cooperation and knowledge exchange	Literature review, analysis of the EIP-AGRI Operational group projects database, good practice database, case studies, interviews
Risk management	Literature review, case studies, interviews

Source: Study team

Overview of findings per CAP instrument

A diversity of CAP instruments support CCA in agriculture as depicted in Table 23. We present the instruments individually, though they are interlinked, particularly within green architecture.

Enhanced conditionality plays an essential role in promoting sustainable soil management and soil health, combating erosion and supporting water retention capacity in soils. It applies to CAP beneficiaries of direct (or basic income support) payments, as well as area- and animal-based payments under EAFRD. The role of conditionality may be weakened following the two recent CAP simplification packages (2024, 2025) depending on the application of exemptions and flexibility by MSs. Eco-schemes and AECC are voluntary for farmers and support a wide range of farming practices relevant to adaptation to

⁵⁰ The JRC developed a classification scheme of farming practices to facilitate the systematic reporting, and evaluation and monitoring processes of interventions defined in the MS CAP Strategic Plans.

⁵¹ As CAP instruments are designed in the CAP Strategic Plans, most findings are available at the national level (regional in the case of Belgium). To assess the sectoral level, specific attention is given to sectoral interventions (wine, olives, fruits and vegetables). To address the regional and local levels, case studies, interviews and FGDs provide a key source of information. These are used to provide specific illustrations.

CC, including water resilience. The latter is also supported by green (productive and non-productive) investments.

Sectoral interventions support CCA especially with new crops or crop varieties (including conversion of vineyards), precision farming, pest control and other farming practices. Cooperation through EIP-AGRI Operational Groups and some Local Action Groups (LAGs) elaborate bottom-up responses notably to local agriculture related climate impacts. Other forms of cooperation can also be supported under article 77 of CAP Regulation, sometimes in combination with AECC. Natura 2000 and Water Framework Directive Payments (WFD) under article 72, which compensate farmers for certain mandatory requirements stemming from the implementation of the WFD and the Birds and Habitats Directives⁵², can also contain obligations which are relevant for CCA. However, support under this instrument, on average, represents only around 1% of total public EAFRD expenditure at EU level. Insurance included as part of risk management tools covers income losses notably incurred because of climate damages in MSs that have implemented this intervention.

Table 23. Main findings per CAP instrument

CAP Instrument	Main findings
SMR	SMR1 under conditionality is linked to the Water Framework Directive (WFD) which sets out obligations, notably to control water abstraction and storage. It aims to promote good water management practices, prevent overextraction and establishes a connection between area- and animal-based payments and the regulation of abstraction and impoundment. Failure to comply with permit conditions is considered a breach of SMR1 and can result in reduced CAP payments ⁵³ . According to literature, interviews, case studies and focus groups, the introduction of SMR1 in the CAP 2023-2027 reinforced the links between the CAP, the WFD and the third RBMPs. However, implementation remains challenging, as SMR1 is only effective if abstraction permits are revised (by MS water authorities) to reflect actual water availability and if water metering is applied and monitored.

⁵² Directives 2009/147/EC) and 92/43/EEC

⁵³ Since July 2023, the regional environmental agency ARPAE Emilia-Romagna has operated an online portal to regulate water abstraction during the summer months. This system is designed to ensure compliance with the Minimum Vital Flow (Deflusso Minimo Vitale – DMV) requirements of watercourses (source: case studies)

CAP Instrument	Main findings
GAECs	GAEC standards were reinforced at the start of the 2023-2027 period, with several of the nine GAEC contributing to CCA. The main GAEC supporting CCA are GAEC 2, 4, 5, 6, 7, 8 followed by GAEC 9 and 1. GAEC 2 (protection of wetland and peatland) plays a key role for water retention, for filtering and storing water and preventing fires. GAEC 4, 5, 6 and 7 address soil health. GAEC 5 concerns areas under risk of (mainly water runoff related) erosion (slope gradient, soil type) and includes adapted practices (e.g. soil management and cropping systems enhancing soil structure including tillage management, ban on certain erosive crops). In 2023-2025, the area at risk of erosion (i.e., area identified by the MS according to a given slope degree) is very roughly estimated at 3% of the net area of arable land (Chever et al. 2025). GAEC 6 concerns the coverage of soils in sensitive periods (mainly autumn and winter). A large majority of CSPs, 25 of 28, set requirements to ensure minimum soil cover of 80-100% of arable land. GAEC 7 preserves the soil potential through crop rotation (EU CAP Network, 2024) and concerns 97 million hectares (Chever et al., 2025). GAEC 8 regarding the obligation to devote a share of arable land to non-productive areas and features is also relevant for its support to increasing water retention capacity of the soil. It was removed and can instead be supported by voluntary eco-scheme to maintain non-productive areas or create new landscape features. The two CAP simplification packages (Regulation (EU) 2024/1468 and COM (2025)) introduced changes related to GAEC standards. Exemptions from certain GAEC requirements (4, 5, 6, 7, 9) were introduced, based on criteria like soil types, crops, farming systems, or damage to permanent grasslands. It also allowed temporary derogations from GAEC requirements due to adverse weather conditions. Depending on the implementation of exemptions and use of flexibility by MS, these amendments may weaken mandatory implementation of FP in support to CCA for CAP beneficiaries.
Eco-schemes, AECC and green investments	These interventions are voluntary for farmers and support the implementation of a broad range of environmentally and climate friendly farming practices. In the Mediterranean bioclimatic region subject to water scarcity, key areas of support relate to soil management, crop rotation and diversification and landscape features. A detailed analysis is presented in the section below.
Sectoral interventions	Sectoral interventions support CCA especially with new varieties (including conversion of vineyards), precision farming, pest control and other adaptation related FP. The literature, case studies and interviews highlighted that interventions in the fruits and vegetables sector in Spain provide varied support. Overall, it covers precision farming (including precision irrigation), bio stimulants, new varieties, management and good practices, especially pest control. In the wine sector interventions support conversion of vineyards but also changes in farming practices. If investment in irrigation is supported under sectoral interventions, these are aligned with the WFD as stipulated in the respective regulations (Commission Delegated Regulation (EU) 2025/1159 of 31 March 2025 correcting Delegated Regulation (EU) 2022/126 supplementing Regulation (EU) 2021/2115). Support to irrigation is not included in the French strategy of adaptation for the wine sector and prohibited by most quality schemes. In the olive sector in Spain only traditional production of dryland olive groves is supported by an associated income support. The traditional olive sector in Portugal is supported through the '<i>Culturas Permanentes e Paisagens Tradicionais</i>' intervention for low-intensity groves of traditional landscapes.

CAP Instrument	Main findings
Cooperation	Cooperation's main components include EIP-AGRI Operational groups (OGs) and LEADER LAGs. These intervene at the local level, addressing local needs through bottom-up and innovative approaches. The EIP-AGRI OGs' database was analysed for the 2014-2022 period. Out of the 3 779 projects extracted from the database, 200 projects were identified as directly related to water management with 72% of those related to irrigation such as through precision agriculture⁵⁴. Most of these are in the Mediterranean biogeographical region (65 in IT, 63 in ES). LEADER LAG projects address the many and varied needs of European territories, as identified by the involved stakeholders. Many LAGs have worked on the theme of 'CC/environment adaptation to CC and water resilience' in 2014-2022. From the good practice database, ten projects appear CCA, but only one is related to agriculture (Pilot carbon footprint reduction with innovative dairy product using at the same time waste from the dairy and wine industry in Greece (2022)). Finally, article 77 of the CAP regulation provides the opportunity for MS to propose diverse cooperation formats beyond LEADER and the EIP-AGRI. This is for instance the case for intervention I.77.4 in NL which was planned to facilitate landscape-scale responses (coordinated water retention, habitat restoration etc.) through multi-actor cooperation. This approach is, however, not used widely across MS. Cooperative approaches can also be supported under AECC (Article 70). An example of a cooperative AECC approach (intervention EL-0101-05) was implemented by two German regions, in Brandenburg/Berlin and Rhineland-Palatinate to enable groups of land managers to jointly plan and deliver site adapted climate protection measures operating at landscape scale.
Knowledge Exchange and advisory services	Knowledge exchange and dissemination of information, under Article 78 of Regulation 2021/2115 cover actions to promote innovation, training and advice and other forms of knowledge exchange. It must support at least one Specific Objective of the CAP while targeting the protection of nature, environment and climate. It can include advisory services through Agricultural Knowledge and Innovation Systems (AKIS), education, preparation of plans or studies etc. AKIS plays an important role to strengthen the links between research and practice (including on CCA) and to foster knowledge flows between advisors, farmers, researchers and public authorities.
Risk management tools	Risk management under the CAP (Article 76) refers to tools and support to help farmers manage production and income risks beyond their control. MS can support risk management tools such as financial contributions to insurance premiums and mutual funds that assist in compensating losses (production and income loss including from natural disasters). Inclusion of risk management tools (RMT) in CSPs remains limited and uneven (14 MS, with more important shares in FR, IT, NL). Under Pillar 2, these help farmers manage risks by covering part of the cost of premiums for crop and livestock insurance and to encourage farmers to adopt insurance as a proactive strategy for mitigating losses from adverse climate events.

Source: Study team

Focus on eco-schemes, AECC and green investments based on farming practices

Eco-schemes, AECC and green (productive and non-productive) investments are the main CAP green interventions defined in Regulation (EU) 2021/2115. These are the main instruments in financial terms contributing to Specific Objectives (SO) SO4 (CC) but also to SO5 (sustainable development and efficient management of natural resources such as water, soil and air) and SO6 (biodiversity, ecosystem services, habitats and landscape). While SO4 is

⁵⁴ Project data was extracted and cleaned using dedicated text mining algorithm. Hence, out of the 4 282 projects available in the database from 2014 onwards, 88% of the data provided sufficient information to be analysed. While this means that a potential bias could be introduced, the number of available projects in the cleaned dataset is deemed sufficient to provide a representative sample.

directly related to climate, SO5 and SO6 also contribute to CCA through increased water resilience to droughts, heavy rainfall, pest and diseases.

PMEF result indicators provide a first overview of the potential support to the three specific objectives (mainly in terms of Utilised Agricultural Area). They are used for target setting and to measure progress towards those targets (performance review). Twelve PMEF result indicators capture the CAP support to climate adaptation and its various dimensions⁵⁵. These result indicators are not only linked to SO4, but also to SO5 and SO6 meaning that the understanding of the link between these result indicators and CCA may be heterogeneous across MS. In addition, most interventions are designed to address multiple needs and specific objectives (SO), and MS had diverging approaches in assigning links⁵⁶. To address this issue, the methodology, based on farming practices was implemented (farming practices are included in the CSP's and assessed by the JRC).

⁵⁵ Currently, 12 PMEF result indicators support adaptation to climate change. In addition to R12 (share of UAA under supported commitments to improve adaptation to climate change and climate action – CCA) and R16 (investments related to climate change adaptation and mitigation) explicitly linked to CCA, the following result indicators are linked to climate and water resilience: R14 (carbon storage in soils and biomass), R17 (afforested land), R19 (improving and protecting soils), R21 (protecting water quality), R22 (sustainable nutrient management), R23 (sustainable use of water), R24 (sustainable use of pesticides), R26 (investments related to natural resources), R29 (organic farming); R34 (preserving landscape features).

⁵⁶ MS had relative flexibility to allocate PMEF indicators to interventions: some used a conservative approach (linking interventions to few indicators only) while others linked interventions to a broader range of indicators. Furthermore, these 12 result indicators are linked to various SOs beyond SO4 (climate action) and are in some cases linked to soil and water (SO5) or biodiversity (SO6) although they play a major role in CCA. This means that the allocation is not homogeneous across CSPs and that the CAP contribution to CCA is likely underrepresented through the analysis of PMEF result indicators and their links to SOs.

Methodology to assess the contribution of eco-schemes, AECC and green investments based on farming practices

In 2024, the JRC developed *A classification scheme based on farming practices from CSPs*, which was used to detail the farming practices (FPs) supported by green interventions (i.e., eco-schemes, AECC and investments (but not Natura 2000 and WFD payments) linked to SO4, SO5 and SO6) in each CSP, at the level of unit amount* (Angileri et al., 2024). The classification provides a common framework to report on CAP interventions supporting farm practices beneficial to the environment, climate and animal welfare. To carry out the assessment based on these farming practices, the study team proceeded as follows:

1. Identification of JRC farming practices related to CCA and water resilience, based on the inventory (see SQ1 Section 2.1)
2. Identification of unit amounts with at least one farming practice related to CCA and/or water resilience, based on the inventory, at tier-2 level.
3. Rough estimation of EU planned expenditures at unit amount level, by multiplying the unit amount by the targeted area indicated in the CSP. When the targeted area was not available at unit amount code level but only at intervention level, the planned expenditures at unit amount level were estimated. This was done by: 1) calculating the targeted areas based on 2024 expenditure data; or 2) if no other data were available, by dividing the intervention planned expenditures by the number of unit amounts linked to this intervention.
4. Rough estimation of EU planned expenditures linked to CCA and water resilience, based on steps 1 to 3.
5. Rough estimation of EU 2024 expenditures linked to CCA and water resilience using SFC data, to assess whether planned area-based payments are taken up by farmers.

This analysis provides more detailed and concrete information on MS support to adaptation compared to the use of PMEF result indicators. However, it is subject to the following hypotheses and limitations:

- Each unit amount is usually linked to several farming practices, the implementation of which depends on the design of the intervention. When one of these practices is linked to CCA, the entire unit amount is considered as supporting CCA, as it is not possible to isolate the funding or area attributable to a specific FP. In addition, when comparing different FPs, double counting applies. Hence, the figures must be interpreted as indicating the potential to support CCA, rather than the actual contribution to CCA.
- Estimates are expressed in terms of EU planned expenditures at unit amount level and not in terms of hectares or livestock. This means that the analysis provides key information on the FPs supported by Member States and the intensity of funding, but not on the agricultural area supported by FPs.
- MS have designed their interventions in different ways. Some MS have fewer but broader interventions (e.g. eco-scheme in France, which targets many farming practices). Others propose more numerous and detailed interventions (e.g. Spain and Greece, which designed various eco-schemes structured into multiple unit amounts targeting more specific farming practices). Therefore, the intensity of funding depicted in the analysis varies across Member States depending on the design of interventions. It does not reflect the actual implementation of farming practices.

* A unit amount is the amount paid to farmers for a supported practice, expressed per hectare or livestock head. Many MS interventions are structured into several unit amounts e.g., for a given eco-scheme or AECC, different unit amounts can be paid depending on the uptake of the intervention.

The analysis of JRC farming practices based on the inventory (SQ1) led to the selection of farming practices relevant to adaptation and supported by the CAP. Figure 13 shows the farming practices relevant to water resilience specifically. The figure shows that a diversity of farming practices can support water resilience, from grassland and soil management, crop rotation and diversification to organic farming to measures to reduce and limit irrigation or to improve irrigation efficiency. The impact of these farming practices on water

resilience depends on their implementation and combination with other farming practices at parcel, local, regional and national levels. As shown in previous SQs, adaptation is highly context-specific and depends on the climate impacts to address. The purpose of this section is therefore to assess how CAP instruments can potentially support water resilience and adaptation. Figure 14 shows the farming practices relevant to other climate impacts.

Figure 13. Farming practices relevant to water resilience

FP Category	Relevant FP at tier 2 / tier 3				Link to water resilience
EX	E1X Precision agriculture				Addresses water use efficiency through targeted irrigation and monitoring technologies.
GX	G12 None or restricted grazing	G14 Livestock seasonal movement	G16 Rotational grazing	G221 Mowing restriction on timing	Contribute to vegetation cover, soil structure, and land use intensity, all of which impact water infiltration, retention and runoff dynamics.
	G222 Mowing restriction of number of cuts	G223 Other mowing restrictions	G23 Idling/resting of grassland	G24 Reseeding on grasslands	
LX	L1X Presence of landscape features	L3X Agroforestry	L5X Management of wetland/peatland		Contribute to shaping the distribution of vegetation, tree cover, and water-retaining ecosystems which interact with water retention, infiltration and surface runoff.
OX	O1X Organic farming				Involves soil-building practices and input restrictions which interact with water retention, infiltration and irrigation needs.
RX	R1X Crop rotation or crop diversification				Improves soil structure and health and prevents soil degradation leading to better water infiltration and retention.
SX	S1X Tillage	S2X Soil cover	S3X Machinery use	S4X Other practices to combat erosion	Shape soil compaction, erosion exposure, and surface cover, which influence water retention, infiltration and absorption.
WX	W14X Measures related to Irrigation	W15X Infrastructure to store water	W16 Sustainable water management on paddy rice fields	W17X Drainage	Direct role in regulating water availability, distribution and retention in agricultural systems.
ZX	Z2X Agrobiodiversity				The diversification of crop and livestock systems can influence water demand and the resilience of agricultural production under water availability.

Source: Study team, based on inventory (SQ1) and JRC, a classification schemes of farming practices

Figure 14. Farming practices related to other climate impacts

FP Category	Climate Risk	Farming Practice	Link to Other Climate Impacts
AX	Heat Stress	A13 Improved access to water	To mitigate the physiological and environmental impacts of elevated temperatures on livestock and pollinators. Includes environmental modifications that reduce exposure to heat, nutritional strategies that support metabolic stability, and welfare interventions that help animals adapt physiologically and behaviorally to thermal stress.
		A14 Feed additives	
		A15X Optimised feeding plans	
		A5X Improved housing conditions	
		A6 Other animal welfare practices	
		A7X Beekeeping	
AX	Diseases	A22 Trait selection for disease resistance	Strengthen systemic resilience by reducing exposure to biological risks and supporting stable production.
		A33 Biosecurity and hygiene measures	
AX	Droughts	A12X Feed from farm	Contribute to maintaining system productivity and manage pressure on natural resources under conditions of limited feed, water and land availability.
		A8 Livestock density limits	
		A23 Trait selection for longer lifespan	
BX	Droughts, heat stress	B2X Renewable energy production	Renewable energy production practices (e.g. agrivoltaics) to simultaneously address heat stress, water scarcity, and energy dependence within agricultural systems.
FX	Drought	F2X Fertilisation practices to reduce nutrient losses	To support plant establishment and productivity under dry conditions, without requiring structural changes to existing production systems. These FP reinforce the capacity of agricultural soils to buffer against water stress.
		F3X Soil amendments	
		F4X Use of specific fertiliser types or manure	
PX	Pest and diseases	P1X Non-chemical control	To address the resilience of cropping systems to ecological pressure, shifting pest dynamics and extreme weather events.
		P3X Integrated production	

Source: Study team, based on inventory (SQ1) and JRC, a classification schemes of farming practices

Figure 13 and Figure 14 show that, through their interventions, MS support a wide variety of farming practices relevant to water resilience and adaptation⁵⁷.

Many of these practices can contribute to addressing water resilience as shown in Figure 13. This includes FP addressing **water management** (WX) which can be linked to area-based payments and investments. The following practices are considered: limitation in water use (W14X)⁵⁸, water storage (W15X)⁵⁹, water management paddy rice fields (W16) and drainage (W17X) especially through drainage bans (W171) and restrictions (W172)⁶⁰. In addition, other FP such as grazing and grassland management, landscape features, soil management (soil cover, crop rotation, diversification, organic farming and agrobiodiversity)

⁵⁷ All CSPs supported farm practices relevant to CCA through eco-schemes, AECC and investments (figure 2-7 and figure 2-8). FPs related to animal welfare (AX), landscape (LX), organic farming (OX), plant protection (PX), crop rotation and diversification (RX) and soil management (SX) are supported by all CSPs. All CSPs except RO supported agrobiodiversity (Z2X). All CSPs except LU and DK supported water (WX) (the latter not considering irrigation expansion). 25 CSP supported fertilisation and soil amendments (FX) (all except BE-WAL, DK, FI). 23 CSPs supported precision agriculture (EX) (all except AT, CY, HR, LT, LU). 22 CSPs supported grassland and grazing (GX) (all except CY, DK, FI, LV, MT, NL).

⁵⁸ W14X includes no irrigation (W141), irrigation limitations in quantity and rates (W142), improve water efficiency measures (W143), limitation in the use of irrigation methods to reduce the use of water (W144)

⁵⁹ W15X includes the use of infrastructure to store water, covering systems to catch rainfall (W151), infrastructure to store water abstracted from rivers or groundwater (W152) and temporary storage of floodwater on agricultural fields (W153). As mentioned in previous SQs, water storage solution can only increase water resilience if carried out in a sustainable way (e.g. without pressuring groundwater resources). In total, 15 MS support W15X through investments (with DE also supporting W15X through AECC), but none provide details at tier-3 level.

⁶⁰ W17X also includes drainage maintenance (W173) and drainage installation (W174) which are less relevant in terms of adaptation than drainage ban (W171) and drainage restrictions (W172). However, drainage maintenance and installation are only specifically targeted in 3-unit amounts (in ES and PT). 55 unit amounts are linked to W171 (in HR, CZ, DE, IE, IT, RO, SK), 70 unit amounts are linked to W172 (DE, LI, PL, SL) and 30 unit amounts (AT, BE-FL, BE-Wal, FI, HU, LT, PT, RO, SE) are linked to W17X without details at tier-3 level.

contribute to improved water retention and filtration, thereby addressing water demand. **Precision agriculture** addresses water resilience by improving irrigation efficiency (if no rebound effect is observed).

As shown in Section 2.2, while changes in irrigation can contribute to adaptation by hydrating crops during droughts or reducing water use per plant (e.g. when irrigation is modified to achieve better targeting and adjusting volumes), it also entails risks of maladaptation if not implemented in a sustainable way (i.e., if it is not paired with steps to reduce overall water use in water stressed regions and to minimise negative externalities). The CAP 2023-2027 introduced safeguards to manage this risk by 1) integrating SMR1 (related to controls on abstraction and impoundment) into the enhanced conditionality, and 2) explicitly aligning the CAP with the WFD for any support related to investment in irrigation or water storage (Regulation (EU) 2021/2115, 2021; Commission Delegated Regulation (EU) 2025/1159, 2025).

This means that CAP support for irrigation or water storage is linked to the status of the relevant water bodies. Depending on this status, different types of investments may be supported, and under different conditions (with or without an effective reduction in water use). However, the concrete implementation of these safeguards varies across MS (see SQ6.3, section 2.6.3). For instance, SMR1 is only effective if abstraction permits are revised by MS water authorities to reflect actual water availability and if water metering is applied. According to the focus groups and interviews, there is also room for interpretation by water authorities in MS regarding what constitutes the 'good status' of a water body .

The farming practice W14X, which concerns **limiting water use**, is often linked to investments aimed at increasing irrigation efficiency⁶¹, as shown in Figure 13 and Figure 15. W14X only concerns modernisation of existing infrastructure, it does not relate to new irrigation infrastructure. Interventions linked to W141 (no irrigation) are supported by area-based payments only and are rarely used in the CSP's.

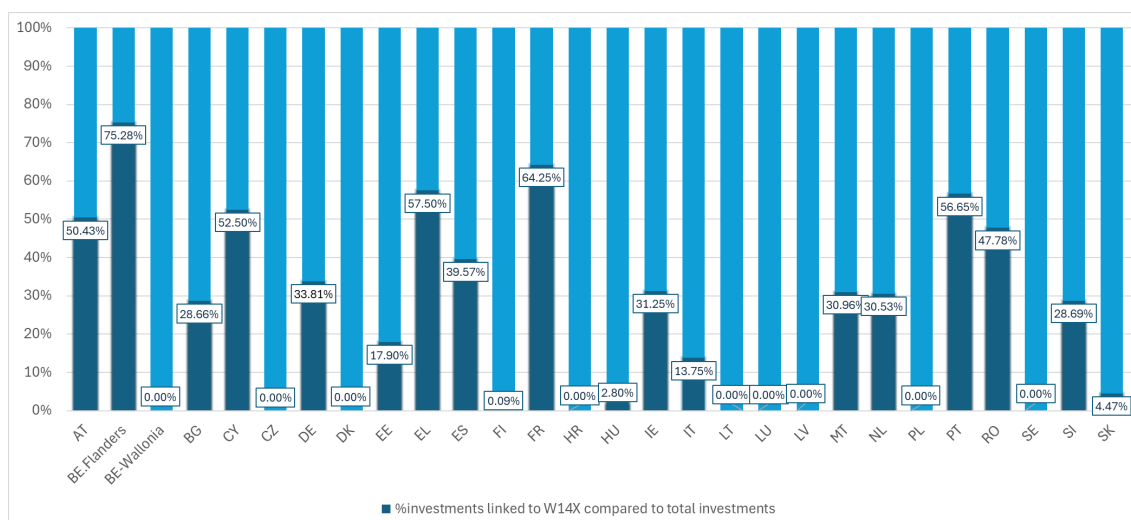
Figure 15 shows a rough estimate of the share of EU planned expenditures for investments linked to W14X at intervention level (data not available at unit amount level for investments). The second column shows the share of investments linked to W14X compared to the total investments planned by the MS (in terms of EU planned expenditures). **These figures should be interpreted with care**, as the **interventions linked to W14X may also support types of investments beyond irrigation**. For example, Spain's intervention 6842.1 - aid for investments with environmental objectives in processing, marketing or development of agri-food products, which is linked to W14X, supports measures to improve water-use efficiency in industrial

⁶¹ The agrifood data portal does not differentiate investments under Article 73 and Article 74 meaning that these investments cannot be isolated based on the available data.

processes, but it also promotes energy efficiency in facilities and the use of renewable energy sources.

Nineteen MS (all except BE, CZ, DK, HR, LT, LU, LV, PL, SE) support investments linked to W14X. This represents 64 investments (interventions) linked to W14X. Out of these, 62 are linked to W143 specifically (improved irrigation efficiency), with CY and PT also supporting W142 (irrigation limitation in quantity and rates). Two investments in Spain are linked to W14X (with no detail at tier-3 level).

Figure 15. Rough estimate of the share of investments linked to W14X (measures related to modernisation of irrigation, except new irrigation infrastructure) compared to total planned EAFRD budget for investments



Source: Study team, based on data extracted from the Agri-food data portal.

Focus on the Mediterranean biogeographical region based on farming practices

MSs from the Mediterranean biogeographical region especially face water scarcity. To better understand how these countries support water resilience through the CAP, Table 24 shows a very rough estimate of the EU planned expenditures for the 2023-2027 period linked to water-resilient FPs (see Figure 13 above) per intervention for EL, ES, IT and PT. The table shows that these countries **all have over 50% of the budget for eco-schemes, AECC and green investments also linked to FP which can contribute to water resilience**. Spain has the highest contribution (74%) followed by Greece (70%) Italy (60%) and Portugal (59%). Eco-schemes are the main intervention in terms of budget contributing to water resilience linked FPs for all MS, except in Portugal where AECC play a greater role. While this does not mean that the whole budget shown below specifically targets water resilience (as an

intervention can cover many aspects), it shows that a significant share can support water resilience⁶².

Table 24. Overview of CAP support to FPs linked to water resilience in Italy, Spain, Portugal and Greece in EU planned expenditures (2023-2027, in million euros)

MS	Intervention	EU planned expenditures linked to water resilience	Total planned EU expenditures	Share of planned expenditures linked to water resilience
Greece	Eco-schemes	1 880	2 175	86%
	AECC	257	690	37%
	Green investments	76	277	27%
	Total Greece	2 213	3 142	70%
Spain	Eco-schemes	4 474	5 553	81%
	AECC	1 052	1 444	73%
	Green investments	551	1 202	46%
	Total Spain	6 076	8 199	74%
Italy	Eco-schemes	2 420	4 439	55%
	AECC	1 384	2 143	65%
	Green investments	1 050	1 528	69%
	Total Italy	4 855	8 110	60%
Portugal	Eco-schemes	440	621	71%
	AECC	451	969	47%
	Green investments	384	575	67%
	Total Portugal	1 276	2 165	59%
Grand Total		14 420	21 616	67%

Source: Study team, based on data extracted from the agrifood data portal

To better understand which specific farming practices MS support in relation to water resilience, Table 25 presents a very rough estimate of the share of EU planned expenditures associated with relevant FP. These shares are calculated relative to the total EU-planned expenditures for eco-schemes, AECC, and green investments in the given MS linked to water resilience. As a single intervention encompasses several FPs, double counting applies. The following table therefore aims to give an order of magnitude only.

Table 25 shows that all MS support a wide array of FP linked to water resilience. The most widely used FP concern crop rotation and crop diversification (R1X) and soil cover (S2X). Farming practices related to landscape features (L1X) are strongly supported by Spain and Portugal. This includes support to creation and maintenance of small wetlands (L14X) in Spain, Italy and Portugal. Italy and Portugal provide strong support to precision agriculture (EX).

On FP related to water management, all MS support measures related to irrigation (W14X) and to infrastructure to store water (W15X). These are supported through both area-based payments and investments. Only ES supports 'no irrigation' (W141) through AECC but ES, IT and PT all support

⁶² The study team also analysed the data on the CAP expenditures for 2024. The analysis of the 2024 data on area-based payments corroborates the findings set out in this section, with a similar order of magnitude.

'limit in irrigation' (W142) (mainly through AECC but also through investments). Measures to improve irrigation efficiency (W143) are widely supported by all MS through eco-schemes, AECC and investments. EL, ES, IT and PT all support water storage (W15X) through investments but no details are provided at tier-3 level. This for instance concerns investments to modernise irrigation infrastructure in ES, IT and PT and investments for land improvement infrastructure projects in EL.

Finally, ES, IT and PT implement interventions linked to drainage (W17X), with IT supporting drainage bans (W171) through AECC, ES and PT support drainage maintenance (W173) through investments (in ES) and AECC (in PT). ES also supports drainage installation (W174) through investments. A majority of interventions linked to these FP are linked to other FPs as well (such as precision agriculture, landscape features, soil management etc.). The scale of impact these interventions have on water resilience depends on their design and specific implementation by farmers.

Table 25. Estimate of the share of MS support to water resilience FP compared to MS's overall support to water resilience through eco-schemes, AECC and green investments

FP code	FP	Greece	Spain	Italy	Portugal
E1X	Precision agriculture	1.81%	1.39%	18.99%	18.25%
G12, G14, G16, G221, G222, G223, G23, G24	Grassland and grazing FP related to water resilience	0.15%	1.71%	17.34%	5.56%
L1X	Presence of landscape features	3.59%	15.50%	1.93%	43.41%
L3X	Agroforestry	3.01%	0.87%	0.46%	5.96%
L5X	Management of wetland/peatland	0.00%	0.01%	0.10%	1.30%
L61	Splitting fields	0.00%	0.00%	0.00%	0.00%
O1X	Organic farming	63.65%	12.86%	18.40%	12.47%
R1X	Crop rotation or Crop diversification	18.42% ⁶³	50.67%	24.21%	17.30%
S1X	Tillage	0.00%	33.54%	0.00%	8.15%
S2X	Soil cover	10.86%	36.82%	54.00%	11.06%
S3X	Machinery use	0.00%	1.38%	0.15%	0.00%
S4	Other practices to combat erosion	1.55%	4.08%	2.45%	2.82%
W14X	Measures related to irrigation	4.05%	5.84%	9.96%	35.19%
W15X	Infrastructure to store water	0.84%	3.09%	3.07%	9.65%
W16	Sustainable water management on paddy rice fields (e.g. late drying up of paddy rice fields)	0.00%	0.58%	0.22%	0.00%
W17X	Drainage	0.00%	3.09%	0.08%	9.81%
Z2X	Agrobiodiversity	12.03%	2.24%	1.41%	11.91%

⁶³ A detailed assessment of the FP included under R1X shows that Greece is the only Member State specifically supporting the adoption of less water demanding crops (R123). Other MS may support less water demanding crops through their interventions, but these are not identifiable through the JRC classification of FP.

2.6.2 SQ6.2 Which other policy instruments with relevance to climate and water resilience have been implemented at national, regional, local and sectoral level?

This section focuses on the main EU policy instruments relevant to climate and water resilience. According to the platform Climate-Adapt, which provides an overview of EU funding for climate adaptation, Horizon, LIFE and the Recovery and Resilience Facility (RRF) all support adaptation efforts in the EU (Climate-Adapt, 2025). The EIB also supports CCA in the agriculture sector by giving loans to private actors via commercial national banks. The EU Cohesion Policy provides important support to CCA including in support to water management, but it does not target farmers or the agricultural sector. These infrastructures can nevertheless have significant effects on agriculture. In addition, the WFD and RBMP play a major role in the way agriculture can adapt to CC, according to the status of water bodies. Overall, all these EU policy instruments are implemented in the different regions and territories of the EU.

Figure 16 shows the total financial envelope of each instrument, and their main links to CCA in agriculture. The assessment is based on a literature review (including analysis of CSPs), the analysis of databases (CINEA database, Cordis, Kohesio database, EIB project database) and interviews at EU level and with beneficiaries.

Each of these policies supports CCA from a different angle:

- Horizon fosters innovation in response to CCA needs, trying to bridge the gap between science and practice. This is mainly done mainly through transnational, multi-actor approach projects, thematic and advisory networks (and recently the Missions) as well as partnerships: scientists and end users are included in projects from the start.
- LIFE, as for Interreg and the OGs of the EIP-AGRI, works more concretely on the ground, responding to the needs of local actors.
- The RRF supports investment in the modernisation of irrigation infrastructure in the Mediterranean MS that include such measures in their national RRFs. Eligible measures include replacing open-air ditches with pipes, installing meters and remote management systems and implementing water regulation systems such as reservoirs. These interventions are designed to improve water-use efficiency in compliance with the DNSH principle.
- The Cohesion Policy supports large-scale investments that often have significant indirect effects on agriculture.
- The WFD is the regulatory framework to protect and, where necessary, restore water bodies to reach good chemical and ecological status and to prevent deterioration.

Figure 16. Overview of other policy instruments relevant to CCA

Policy Instrument	Main links to CCA
Horizon Programmes: • Horizon2020: €80 billion • HorizonEurope: €93.5 billion	Research, development and deployment of innovative solutions to address societal challenges, including climate change in agriculture.
LIFE • 2014-2020: €3.4 billion • 2021-2027: €5.4 billion	EU funding instrument for environment and climate action, notably aiming to provide solutions to foster CCA through bottom-up approaches.
EU Cohesion Policy €392 billion for 2023-2027	Support to cities and regions in the EU, including through support to infrastructure projects in access to water, water management and flood prevention.
Recovery and Resilience Facility (RRF) €650 billion (incl €359 billion in grants)	Post covid financial support for MS recovery with 37% target to climate-related measures. Relevant support include support to water network projects, desalination, river restoration etc.
EIB	Support to MS and private sector, including projects related to sustainable water management, R&D, irrigation, flood management, groundwater enhancement.
Water Framework Directive (WFD)	Main law for water protection in the EU to ensure an integrated approach to water management. It encompasses water use, abstraction regulations, water savings and monitoring based on a river basin district approach (River Basin Management Plans (RBMP))

Source: Study team (2025) based on literature, interviews and database analysis

Horizon 2020 and Horizon Europe programmes aim to address key societal challenges through research, development and the deployment of innovative solutions by encouraging the deployment of cross-disciplinary, cross-sectoral and international collaborations. The analysis of the Horizon database⁶⁴ and interviews led to the identification of 206 projects relevant to CCA in agriculture (44 projects under Horizon 2020, 53 under Horizon Europe to which 109 partnerships⁶⁵ were added hence a total of 162). Under Horizon Europe, two Missions are especially relevant to agriculture: EU Mission Soil which promotes the protection and restoration of soils in Europe (reduced desertification, improve organic soil, prevent erosion etc.) and EU Mission on Climate Adaptation. Overall, these projects are very diverse and provide context-specific solutions to a wide range of climate challenges.

Horizon projects are transnational and are implemented in the MS regions and territories. Most of these projects use a multi-actor approach and can be complemented by thematic networks (TN) as well as living labs and lighthouses⁶⁶ since Horizon Europe. In total, three advisory networks, three

⁶⁴ The analysis focused on societal challenges (bioeconomy and climate action) for Horizon 2020 and on cluster 6, Mission Soil, Mission for climate adaptation and Partnerships. The list was shared with relevant EU-level stakeholders to complete and validate the selection.

⁶⁵ European Partnerships bring together the European Commission and private/public partners to address challenges through research and innovation initiatives. Key partnerships identified as relevant to CCA are the Partnership for Research and Innovation in the Mediterranean Area (PRIMA) which focuses on developing knowledge and innovation related to water management, farming systems and food value chains, as well as Agroecology Partnership to accelerate the transition towards agroecology in Europe.

⁶⁶ Lighthouses under Horizon programmes are places for demonstration of innovative solutions, learning and trainings through a multi-actor approach.

thematic networks and one living lab were identified as relevant to CCA for Horizon2020⁶⁷. For Horizon Europe, this includes 14 living labs and 2 thematic networks⁶⁸. They cover many topics, ranging from **water management** (irrigation, water retention, water storage), **regenerative farming systems**, **nature-based solutions**, climate services and weather forecasting, agroecology and agroforestry and exchange of good practices on these topics. While some projects focus on a specific sector (livestock farming, mixed farming, fruits and vegetables, wine, olives, horticulture) or specific crops (e.g. tomatoes, potatoes, barley, oats) at farm-level or at value-chain level, some projects work on providing solutions to the agriculture sector as a whole (e.g. projects working on weather forecasting, climate projections, landscape restoration projects).

Zoom on MIP4Adapt

The [Mission on Adaptation to Climate Change](#) started in 2021 and aims to support European regions and communities towards climate resilience by 2030 through a greater understanding of climate risks, developing adaptation pathways and implementing innovative solutions. MIP4Adapt is the Mission Implementation Platform providing technical assistance to deliver on the Mission's objectives and by facilitating a Community of Practice (CoP) to share knowledge and experiences exchange, via themed events and Thematic Working Groups (TWGs) on engagement, climate services, financing, and monitoring, as well to promoting coordination and collaboration. The Mission supports local and regional authorities to transform climate risk assessments into concrete adaptation plans and projects. It has mobilised over 300 regions and municipalities through MIP4Adapt. The Mission is **cross-sectoral** as it addresses the energy transition, mobility, water management and agriculture, the latter usually being addressed within a broader circular economy framework.

LIFE is the EU's funding instrument for the environment and climate action which aim to address specific needs through a bottom-up approach, notably through a dedicated sub-programme on CCA and mitigation. Based on a keyword search of the LIFE project database, 43 relevant LIFE projects from 2014-2020 period were identified. These include 30 projects directly related to water scarcity, and specifically droughts. However, these often explore a broader range of agricultural adaptation strategies. For instance, the LIFE AgriAdapt project, considered to be one of the most relevant projects identified, tested numerous adaptation measures across 126 pilot farms in Europe. These included practices addressing not only droughts but also other climate impacts such as flooding and soil health.

⁶⁷ Namely, the advisory networks are: Breeding for resilient, efficient and sustainable organic vegetable production; Network for effective knowledge transfer on safe and economic wastewater reuse in agriculture in Europe and Water retention and nutrient recycling in soils and streams for improved agricultural production. The thematic networks are: EU fruit network; Transfer of innovative techniques for sustainable water use in fertigated crops and Managing crop water saving with enterprise services.

⁶⁸ The thematic networks concerned are: Soils for Europe and Nature-based solutions for soil management.

As shown in SQ1 (see Section 2.1), LIFE projects play an important role in this study. Specifically, the results of two LIFE projects (AgriAdapt and Cambia) were used in addition to the JRC farm practices to design the inventory. In addition, evidence collected through the case studies highlight the importance of LIFE projects for CCA in agriculture, such as in Pays de Loire de France with LIFE Artisan (valorisation of nature-based solutions) and LIFE Dynamic Rotative Grazing (sustainable pasture management).

Zoom on GREAT LIFE

GREAT LIFE is implemented in the Po Valley Region in northern Italy, where the production of traditional agricultural crops is under pressure due to rising temperatures and water scarcity. Maize is the main cultivated crop in the region but requires substantial amounts of water. According to the Italian case study, 68% of the water demand in the region is satisfied by surface water (mainly from Po River), but also by groundwater, used for irrigation.

To address challenges related to water scarcity, the project aims to contribute to greater resilience through the experimentation of new, resilient and less water-demanding crops. The project demonstrated that the adoption of sustainable agricultural practices and the substitution of maize with sorghum and millet led to a 20% reduction in water consumption.

The Cohesion Policy supports a wide range of investments in large scale infrastructure projects, including projects designed to prevent natural disasters such as floods and wildfires and improved water management (European Commission, 2025). While these measures can have positive indirect effects on the agricultural sector, the policy does not specifically target farmers, who are not direct beneficiaries of this funding. Nevertheless, these large-scale infrastructures may also support agriculture when it comes to dams or flood prevention. This was notably the case with the Alqueva Dam in the South of Portugal, where the Cohesion Policy, the ERDF, the EAFRD, and ESF started co-financing the dam's construction and associated infrastructure (end of the 1990s), which gradually supported agriculture through expanded irrigation and water distribution networks (European Commission, 1997; European Commission, 2015).

Interreg projects⁶⁹ intervene on a much smaller financial scale than the ERDF. They are nevertheless important. The territorial approach under Interreg translates into collaborative, experimental projects which require cooperation between organisations from different countries to implement on-the-ground activities, notably in response to CC in agriculture (CS, interviews). The Catalonia CS highlights that Interreg can support regional projects with shared challenges such as water scarcity, with funds offering concrete solutions to

⁶⁹ Interreg projects use a bottom-up approach to address regional challenges. Although less important in financial terms than other Cohesion Policy funds, they play an important role in addressing territorial challenges.

Catalan rural actors as well as transmitting good practices across the Mediterranean.

The Recovery and Resilience Facility (RRF) is the centrepiece of NextGenerationEU. It is a one-off instrument which aims to support the recovery post Covid-19 by making funding available to MS through raising funds on the capital market (European Commission, 2025). According to Regulation (EU) 2021/241, the RRF includes a 37% target for expenditure on climate-related measures, including mitigation and adaptation. Evidence from case studies and interviews show that some MS such as Spain and Italy use RRF funding to modernise their irrigation infrastructure.

The National Recovery and Resilience Plan (funded through RRF) aims to renovate the water network in Emilia Romagna. It involves water basin authorities, local reclamation and irrigation consortia and farmers' organisations (CS Italy). The Catalunya case study and interviews show that RRF funding was mobilised to address water scarcity in the agriculture sector. In Spain, the RRF notably supports the modernisation of existing irrigation systems through Investments C3.I1 and C3.I11, which allocate EUR 923 million of RRF funding to modernise 160 000 hectares of irrigation systems (European Commission, 2025). These measures include replacing open-air ditches with underground pipes, installing meters and remote management systems and implementing water regulation systems such as reservoirs. The RRF is subject to different rules than the CAP, as outlined in SQ6.3. According to the CS Catalunya, the RRF also funds measures aiming to support water cycle digitalisation projects, investments in desalination and water reuse, national river restoration plans, wastewater management and reuse (source: CS Spain).

The European Investment Bank (EIB) funds projects related to CCA within the EU. Its Climate Adaptation Plan prioritises investments in sustainable water management, food security and resilience for rural and urban areas, offering financial and advisory support to foster nature-based and climate-resilient solutions. 50% of its lending is directed towards climate action (European Investment Bank, 2020). According to interviews, in 2021, the EIB lent EUR 1.3 billion for adaptation projects, notably by helping intermediary banks identify eligible adaptation actions while applying a framework to avoid maladaptation practices. Illustrative EIB-funded projects include infrastructure initiatives such as the Platys Irrigation Infrastructure and Flood Protection Project in Crete, which supports irrigation, flood management, and groundwater enhancement for agriculture. In October 2025, the EIB published its Climate Bank roadmap to consolidate its role in supporting EU climate and nature goals, doubling its adaptation financing compared to its 2021-2025 volumes.

Under Phase 2 of the EIB Climate Bank Roadmap (2026-2030), published in October 2025, the EIB will double adaptation financing to EUR 30 billion, focusing on agriculture, integrated water cycle management, cities, and vulnerable regions. The roadmap introduces the Water Resilience Programme,

which is linked to the EU Water Resilience Strategy, and aims to support infrastructure upgrades, smart water management and ecosystem restoration to address saline intrusion, water scarcity, coastal erosion and flood resilience. This builds on the EIB's role as a major green bond issuer and its commitment to mobilise EUR 1 trillion in climate investment by 2030 (European Investment Bank, 2025)

Finally, the **Water Framework Directive (WFD; Directive 2000/60/EC)**, adopted in 2000, is the **regulatory backbone for water resilience**. The WFD provides a regulatory framework to protect and, where necessary, restore water bodies to reach good chemical and ecological status and to prevent deterioration. For instance, natural water retention measures are implemented within RBMPs and consist in water retention systems like peatlands or wetlands that bolster climate resilience by reducing storm surges, mitigating floods, and stabilizing shorelines, all while storing carbon. Article 4 of the WFD requires MS to use their RBMPs and Programmes of Measures (PoMs) to this end. The third RBMPs (2022-2027) are the main instruments for implementing the WFD, including updated characterisation of river basin districts, delineation of water bodies and assessment of ecological, chemical and quantitative status, alongside registers of protected areas and monitoring networks. They include revised PoMs to address significant pressures, such as hydromorphological alterations, water abstraction and scarcity, while integrating stakeholder participation and coordination with EU policies like the Floods Directive.

2.6.3 SQ6.3. To what extent are CAP instruments integrated / coordinated with other policy instruments as well as with private funds or initiatives to address different climate impact drivers in different agro-climatic zones and sectors?

Coordination is understood as the extent to which policy instruments establish mechanisms to ensure complementarity towards common objectives. Integration is a step further and includes the process of integrating results/outcomes from other policy instruments to feed the CAP and vice versa, in order to improve the design of instruments, scale-up projects, and capitalise on outcomes by creating synergies, and therefore maximise impact and efficiency in terms of adaptation to CC. Integration is mainly relevant for the WFD and other Union funds active in rural areas (e.g. Horizon and LIFE) as depicted in Articles 109(2)(c) and 110(d)(v) of Regulation 2021/2115.

The literature review, interviews, case studies, focus groups and a review of CSPs provide evidence on the level of coordination and integration of the CAP with other policy instruments.

All in all, other EU policy instruments present varying degrees of coordination and integration to address climate impact drivers in the EU regions. The EIP-

AGRI, Horizon and LIFE all work on projects on the ground to develop solutions to problems faced by farmers. These mechanisms use a common approach and are integrated to varying extents to achieve their objectives (see Table 26). The EIP-AGRI, through its funding architecture, is bridging EU research (Horizon Europe and Horizon 2020 programmes) and the CAP, supporting practical innovation via Operational Groups, advisory services, and other cooperation measures supported by the EAFRD. Thus, EIP-Agri is a functional interface between policies on agriculture, forestry and rural areas. The Cohesion Policy, RRF and EIB take a different approach than the CAP and do not support farmers directly. The Cohesion Policy is coordinated with the CAP to ensure complementarity and avoid overlap of fundings. The CAP 2023-2027 is aligned with the WFD objectives of reaching a good status of water bodies. Explicit links to the WFD are made in Regulation (EU) 2021/2115 (see SQ6.1 and SQ6.2).

Table 26. Level of integration between the CAP and other policy instruments

Instrument	Level	Findings
Horizon programmes	High	The CAP has overall a good level of coordination and integration with Horizon programmes in relation to CCA, through the EIP-AGRI. Nonetheless, the level of integration varies, with a low level of integration with the Mission for Climate adaptation and a high level for the Mission on Soils. The Climate adaptation Mission's engagement structure and Horizon Europe Work Programme make no explicit reference to the CAP, to the EIP-AGRI, or to AKIS (European Commission, 2021). Conversely, the Mission Soil under Horizon Europe explicitly commits to working 'in tandem with the future CAP and its EIP-AGRI (Mission Soil Implementation Plan). Integration is evidenced in 18 of 28 CAP Strategic Plans, leveraging AKIS and EIP networking facilities to replicate solutions through Operational Groups (OGs). Horizon Europe Cluster 6 guidance further mandates practice abstracts in the EIP-AGRI common format and recommends involving interactive innovation groups, confirming the feasibility of such linkages. In contrast, the Mission for Climate adaptation connections with the CAP remain limited to thematic intersections and participation in broader research and innovation initiatives (MIP4Adapt interview notes). EIP-AGRI plays a role in the identification of research needs for CCA-related issues (and beyond) and serves as a platform to disseminate Horizon opportunities and results to interested stakeholders (including farmers) through brochures, seminars, the EIP-AGRI project database, and practice abstracts. Evidence shows that the EIP-AGRI s contributed to the drafting of Horizon calls related to adaptation and that Operational Groups' results were used in thematic networks to scale-up the outcomes of their projects, notably on water scarcity. In addition, the CSPs explicitly mention Horizon programmes and their links to EAFRD interventions. In total, nine CSPs make explicit links with Horizon programmes in relation to CCA (AT, BE-Wal, CZ, EE, ES, LU, NL, RO, SK). In NL, Horizon programme outcomes have been used to strengthen CAP interventions (eco-schemes, AECC and conditionality).

Instrument	Level	Findings
LIFE	High	The level of integration and coordination between the CAP and LIFE projects overall is good. This is mainly established by stakeholders in the field and through the works of the EU CAP Network. As for Horizon, the operational groups of the EIP-AGRI and LIFE both use a bottom-up approach to design projects and to respond to identified needs. At EU-level, coordination between the EIP-AGRI and CINEA is recent and has started to pick up since 2024. The CSPs explicitly mention LIFE and its links to EAFRD interventions. Indeed, according to Article 99 of Regulation 2021/2115, Member States may decide in their CSP to use a share of EAFRD funding to support and upscale integrated Strategic Nature Projects benefiting farmer communities under LIFE. In total, 12 CSPs make explicit links to LIFE in relation to adaptation (CZ, DE, DK, EE, ES, HR, HU, IE, LT, RO, SE, SK). BE-Wal, DK, EE, ES, IE, LT, RO highlight coordination and complementarities between LIFE and EAFRD regarding water issues.
EU Cohesion Policy Funds	Low	The CAP and the EU Cohesion funds have a low level of integration and a strong degree of demarcation. The Cohesion Policy does not intervene at the farm level but at regional/ territorial level. Nonetheless, some projects can indirectly benefit farms, such as infrastructure projects aiming to improve/increase water supply and wildfire/flood prevention. Case studies and interviews highlighted complementarities with Interreg. Only six CSPs explicitly mention the ERDF/ Cohesion Policy (CY, DE, EL, FR, IT, MT) in relation to CCA. This includes water-related projects (water supply, wastewater treatment, flood controls) for CY, EL, FR, IT and MT, and financing for research in rewetting measures for DE.
RRF	Moderate to low	The CAP and the RRF have a moderate level of integration. The RRF was designed to support the post COVID-19 recovery and was therefore established before the CAP 2023-2027. The NextGen EU instrument provided €8.1 billion additional financing to the EAFRD for the 2021-2027 period (European Commission, n.d.-a). Case studies and interviews highlighted large financial envelopes dedicated to water projects in Italy and Spain. These focus on modernization of the irrigation infrastructure, on irrigation efficiency as well as water storage and water supply. The RRF does not explicitly define at the level of the basic act detailed provisions on investments in irrigation based on the status of water bodies affected by the investment, as the CAP does. Instead, it applies the 'do no significant harm' principle to all measures, assessed individually according to Commission guidance (European Commission, 2023a). In addition, nine CSPs explicitly mention the RRF in relation to CCA (BE-FL, BE-WAL, BG, DK, EL, FR, IT, PT, SE). Projects can include measures to enhance water resilience and address droughts, flood risk management, R&D&I (agrisolar, genetic improvements, crop restructuring), and forest management. According to the CSPs, these projects do not intervene on projects supported by the CAP (no double funding).

Instrument	Level	Findings
EIB	Moderate	The CAP and the EIB have a moderate but growing level of coordination and integration, including on CCA. In the 2014-2022 and 2023-2027 period, the EIB provided EAFRD top-ups to four Member (EE, ES, HU, PL). The financing supported investment projects in afforestation and forest management notably to protect against wildfires, water-saving technologies, the plantation of perennial crops and digital transformation of farms to enhance climate action. In addition, the EIB contributed to the knowledge base on insurance schemes including those supported by the CAP with the publication of a study in May 2025⁷⁰. Finally, the EIB invested €0.75 billion in climate adaptation in EU agriculture through commercial banks (i.e., blended finance). Such projects focus on sustainable water use and supply, seeds development, improved fire management and forest management. However, no clear coordination mechanism with the CAP could be identified for these investments. In December 2024, the EIB announced a €3 billion financial package to EU agriculture and bioeconomy in support to young farmers, green investments and farm modernisation (European Investment Bank, 2024).
WFD and RBMPs	Moderate	SMR1 plays a key role in aligning the CAP with the WFD (and RBMPs) and strengthening water resilience (see section 2.6.1). Investment in irrigation supported by Article 74 of the CSP Reg is only possible for MS that have shared a RBMP with the Commission for the entire area concerned by the investment. According to article 74 of Regulation (EU) 2021/2115, Member States may support improvements to existing irrigation systems only if the investment is shown beforehand to save water. If it affects water bodies with less than good status due to water quantity, it must reduce water use to help restore those water bodies to good status. A water-metering system capable of measuring usage at the level of the supported investment must either already be operational or be installed as an integral component of the investment. Sectoral interventions are aligned with the WFD as stipulated in the respective regulations (Commission Delegated Regulation (EU) 2025/1159 of 31 March 2025 correcting Delegated Regulation (EU) 2022/126 supplementing Regulation (EU) 2021/2115). Evidence from the case studies and interviews show that coordination and integration between the CAP and the WFD have been improving in the 2023-2027 period at national level. However, alignment varies across MS according to the implementation of SMR1 and the RBMPs by the national authorities (e.g. if abstraction permits are revised to reflect actual water availability). For instance, AT, IE, IT, HU and RO provide examples of good integration. In Romania, stakeholders from the Ministry of Agriculture, with expertise in the WFD, reported strong collaboration between the Ministry of Agriculture and the authorities in charge of RBMPs, with project eligibility for CAP support determined by water quantity and quality indicators. In Austria, a stakeholder from the Federal Ministry of Agriculture reported that irrigation investments are only permitted when aligned with RBMP objectives, ensuring compliance with WFD. However, concerns were raised in ES, EL, from some IT and DE stakeholders (see SQ6.2).

⁷⁰ FI-compass, 2025, Insurance and Risk management tools for agriculture in the EU.

Instrument	Level	Findings
Private funds and initiatives	Low	Very few private funds and initiatives regarding CCA were identified in the study. As for the EIB, this is also due to the understanding of what is CCA in agriculture. Private funds tend to pursue climate-mitigation objectives rather than CCA, as mitigation has a clear definition which can be clearly communicated and aligns with lower-emissions targets. It is easier to communicate 'low-emission products' to consumers, and some informed consumers are more inclined to buy agricultural products that are presented as having been produced with reduced GHG emissions. The study team, through a review of CSPs, did not identify any private funds and initiatives integrated into the CSPs, except for one private initiative mentioned in the NL CSP.

2.7 SQ7: To what extent can possible gaps and shortcomings in farming practices, tools and strategies to adapt to CC and increase water resilience be addressed at a) regional/local and b) sectoral level through the CAP and by other means?

The study identified the lack of a clear, shared understanding among stakeholders of what it means to adapt agriculture to CC, in light of specific climate risks. CCA in agriculture is highly context-specific, depending on the biogeographical region and the CC impacts involved. Stakeholders largely focus on reactive and incremental adaptation measures that address current impacts rather than underlying vulnerabilities. There is a lack of broad, inclusive stakeholder engagement in the development of long-term strategies, and the involvement of the private sector in designing such approaches remains insufficient. Collectively, these shortcomings hinder the formulation of comprehensive, long-term climate adaptation strategies at regional, sectoral, and local levels. Shortcomings in building water resilience were also identified, although the coherence between the CAP and the Water Framework Directive was reinforced in the 2023-2027 period. The effective implementation by the respective MS authorities and the effective enforcement of environmental legislation, in particular the WFD, is diverse.

2.7.1 Gaps and shortcomings regarding adaptation to CC

The study identified a lack of a clear, shared understanding among stakeholders of what it means to adapt agriculture to CC, considering specific climate risks. CCA in agriculture is highly context-specific, depending on the biogeographical region and the specific risks involved. Stakeholders largely focus on incremental and short-term adaptation measures. There is a lack of broad, inclusive stakeholder engagement in the development of long-term strategies, and the involvement of the private sector in designing such approaches remains insufficient. Collectively, these shortcomings hinder the

formulation of comprehensive, long-term climate adaptation strategies at regional, sectoral, and local levels.

The following gaps and shortcomings have been identified:

- **Lack of a clear, shared concept of CCA (SQ6):** There is no common understanding of what CCA means or encompasses.
 - CC risks vary greatly across EU territories, sectors, and production systems and the response is addressed at different governance levels (farm/ territory/ sector/ region / water bodies). The absence of a clear, shared concept is partly due to the highly context-dependent nature of adaptation, as underlined by all SQs.
 - CCA in the CSP's is directly related to SO4, but it is also addressed through SO5 (soils) and SO6 (biodiversity). When elaborating the CSPs, MS followed very different approaches to identify CCA. Some adopted a restricted approach linking their interventions only to a few SOs and PMEF result indicators, while others used a broader range of SOs and result indicators. In addition, the understanding of the concept of CCA (especially among Managing authorities) has evolved since the elaboration of the CSPs in 2019⁷¹ as notably shown through interviews.
 - The heterogenous approaches adopted by MS to allocate SOs and PMEF result indicators poses limits to monitor CCA in the CAP. Nevertheless, all MS incentivise the implementation of a large range of farming practices in support to adaptation (see SQ6).
- **Incremental and short-term focus of adaptation (SQ1):** Adaptation remains largely reactive and incremental, focusing on short-term solutions to current impacts, rather than building resilience to CC.
 - Implementation typically centres on farm-level practices such as new crop varieties, soil management (including cover crops), improved water efficiency, housing conditions for livestock to address heat stress and physical protection measures.
 - Short-term measures are prioritised over long-term strategies, especially those involving extensification, nature-based solutions and systemic shifts.
 - Monitoring of CCA practices, tools, and their effectiveness across MS is limited, highlighting the need for common monitoring frameworks and policy feedback mechanisms. In addition, there is

⁷¹ Better and more comprehensive understanding of the concept of CCA that includes large components of SO5 on sustainable development and efficient management of natural resources such as water and soils but also biodiversity (SO6). This knowledge has grown since the finalisation of the CSPs in 2021-2022.

limited analysis of how individual practices, tools, and strategies interact to build overall resilience.

- Insufficient involvement of private sector aspects (SQ2, SQ6)
 - Involvement of the private sector, including agro-industries, food processors, and retail and wholesale operators, in developing long-term CCA strategies and scenarios remains limited. They determine which products and varieties are processed and marketed.
 - Banks and other private actors lack a clear understanding of the scope of CCA. They are generally more familiar with CC mitigation and its “low carbon” products, which have consumer marketing appeal, but they have limited understanding of CCA, as shown by focus group discussion 1 and interviews at EU level and with private sector.
 - CCA for geographical indication products and attached value chain is challenging because of the specifications’ limitations and the inherent difficulty (and administrative burden) to change technical provisions. These require products from specific territories, even though, in a long-term CCA strategy, some of these products could be replaced, for example cultivating less water-demanding crops in regions facing water scarcity (source: Focus group 3, Focus group 4, interviews).
- Barriers to adaptation at the level of farmers (SQ3, SQ4):
 - **Financial barriers to adaptation:** Changes in farming systems can result in several years of uncertainty for farmers (SQ3). Currently, the CAP mainly supports changes in farming practices through eco-schemes, AECC (both for income foregone or additional costs), and possibly investment support. Structural financial support during transition periods was reported as insufficient. A lack of funding for costly innovative tools—such as digital solutions and robotics—was also mentioned as a barrier to their implementation (sources: SQ3, SQ4, SQ6, interviews with sectoral groups, case studies).
 - **Uncertainty as a barrier to adaptation:** Uncertainty is a key barrier to CCA, particularly for farmers as shown in SQ3 and SQ4. It influences multiple dimensions, including the extent of future risks, the costs and benefits and feasibility of implementing adaptation measures.
- Limited comprehensive stakeholder engagement: The comprehensive involvement of all stakeholders operating in a given area or sector is often missing in the development of future visions and adaptation

scenarios, although there are examples of good practice (e.g., certain LIFE projects and initiatives in the French wine sector).

- Shortcomings in the link between the Mission for Climate adaptation under Horizon Europe and the EIP AGRI: The European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) was created to build on the strengths of the Horizon programmes and the CAP in a synergistic way. Yet, limited collaboration between the EIP-AGRI and the Mission on Climate Adaptation hinders the support and dissemination of concrete actions on the ground.

2.7.2 Addressing gaps and shortcomings regarding CCA at regional/local and sectoral levels

Through the CAP

This section outlines several possible approaches to address the identified gaps and shortcomings. These are based on the 2023–2027 CAP framework and its support mechanisms, which are mainly available at the local level. CAP support is primarily provided at the level of the agricultural parcel. However, cooperation measures (Article 77) and AKIS (Article 78) could be used more broadly beyond the parcel level, and the potential for integrated support mechanisms is also highlighted.

- Cooperation measures (Article 77): these can support the elaboration of strategies at local level through OGs, LAGs or other forms of cooperation. A few examples of collaborative AECC at landscape level are being implemented in Germany and the Netherlands (see Section 2.6.1).
- AKIS (Article 78): where relevant, MS' AKIS (Agricultural Knowledge and Innovation Systems), including knowledge-exchange (KE) activities, could focus on supporting the development and implementation of CCA practices and tools that enable collective action at local level. This could for instance include the provision of diagnostic tools to help farmers identify their adaptation needs and CAP mechanisms to respond to these needs.
- Support mechanisms for adaptation: Eco-schemes and AECC currently support additional costs and income foregone, and support for investments can also be provided. However, the different types of support are not necessarily integrated, and the funding does not appear sufficient to effectively support long-term adaptation (SQ4). A concept that combines investment support with area-based payments (under eco-schemes or AECC) to support changes in farming practices could help farmers address some of their adaptation needs to CC.
- However, 'nationwide sectoral CCA strategies' (such as the CCA strategy for the Wine sector in France, which is an example of good practice) fall outside the scope of these territorial multi-actor bottom-up

approaches. Their development would require additional national commitment from all value chain actors, as well as support from national funding.

Through other means

The following avenues could support the establishment of a comprehensive strategy involving all stakeholders at regional/national levels beyond the current CAP support:

- The French wine sector strategy rests on a combination of valorisation of existing research, combining awareness-raising, stakeholder engagement, and long-term scenario planning, in support to actively preparing the sector for and adapting to CC. This type of large-scale engagement could be supported by Horizon projects in combination with national support for strategic sectors.
- The Mission on Adaptation to CC should establish structured interfaces with the EIP AGRI (the support unit being included in the EU CAP Network), EIP-AGRI OGs, AKIS, and national CAP networks, by opening Mission Technical Working Groups and the Community of Practice to sectoral advisors and innovation actors, and by designating AKIS liaison functions within MIP4Adapt. The Mission could also adopt an 'Adaptation Practice Abstracts' requirement in the EIP-AGRI common format for all agriculture-relevant outputs, ensuring knowledge flows via the EU CAP Network and Climate-ADAPT. This builds on the Soil Mission's integration with the CAP and EIP-AGRI and its integration in 18 CAP Strategic Plans, leveraging EIP networking facilities and AKIS to replicate solutions through OGs. Enhanced collaboration between the EIP-AGRI and the Mission on Climate Adaptation (Horizon) would facilitate the effective transfer and scaling up of climate adaptation practices.
- Some Horizon calls for proposals could be specifically focused on the implementation of local strategies, with local actors including farmers, in response to water scarcity and other climate-related challenges.

2.7.3 Gaps and shortcomings regarding water resilience

A number of shortcomings in building water resilience remain even though coherence between the CAP and the WFD has been strengthened through the River Basin Management Plans 3 (RBMPs), and safeguards have been implemented. Particularly:

- The CAP 2023–2027 has strengthened its links with the Water Framework Directive (WFD) regarding the quantitative aspects of water management (see section SQ6.2 and section SQ6.3). However, the alignment between the CAP and the WFD varies across MS according to the implementation of SMR1 and the RBMPs by the water authorities.

SMR1 is only effective if abstraction permits are revised by MS water authorities and if water metering is applied.

- The interpretation of Article 74, concerning the effects of an investment on water bodies with less than good status due to water quantity, is determined by MS. Such investments must actually reduce water use to contribute to the restoration of these water bodies to good status.
- If a MS authority determines that an investment in expanding irrigation will not result in significant negative environmental impacts, the CAP-funded investment may proceed. This applies even when other stakeholders express reservations regarding the robustness of the assessment conducted by the MS, including potential CC impacts on future water availability.

Challenges and gaps in water governance

- **Governance approaches vary widely** across MS and regions, in the implementation of the WFD and in the design and implementation of River Basin Management Plans (RBMPs). This divergence leads to **uneven implementation** of water policies and objectives (see SQ5, Section 2.5). The implementation of changes in national and regional legislation since the 'CAP 2023-2027 – RBMP3' is recent and can be slow in some cases (e.g. water metering requirements linked to SMR1). These changes and their implementation are diverse as reflected in case studies (e.g. **France, Italy**), interviews (e.g. **Germany Rhineland Palatinate**⁷²), and Focus group 3 and Focus group 4.
- There are **divergent views** among stakeholders about the improved national integration between the CAP and RBMP (source: Focus group 2, Focus group 3, interviews). Some consider that the **2023–2027 CAP**, including **SMR1** and **Article 74** (investment support) and the rules for support to irrigation under sectoral interventions (see section 2.6.1), has led to improvements on the ground. Indeed, positive experiences of integration between the CAP and national water management frameworks were reported in AT, RO, IT, IE, HU. Others highlight **ongoing issues**, such as continued or even increased **investment in irrigation**, including in **watersheds with poor quantitative status** (ES, PT) and the rebound effect, where improvements in existing installation led to increased efficiency with more water abstraction⁷³. For instance, according to the Focus groups, Hungary combines drought and flood monitoring with basin-level restriction plans, while Romania links project

⁷² As a result of climate change, the available water resources for agriculture in southern Rhineland-Palatinate are no longer sufficient, or more water is needed for irrigation. It has become apparent that the originally approved daily peaks are no longer sufficient; although exceeding these limits is permitted on ten days a year, this value is currently being exceeded more frequently.

⁷³ The unintended consequences of irrigation efficiency policies were also discussed (rebound effect) was discussed in FGD. In regions like Spain, the adoption of improved irrigation technologies has paradoxically led to an increase in total water use, as farms shift toward more water-intensive production systems to pay back the investments. As a result, farms have become highly dependent on water availability, creating challenges during droughts, often requiring public financial compensation

eligibility for CAP support to water quantity and quality indicators through close cooperation between the Ministry of Agriculture and RBMP authorities. However, in water-scarce MS, enforcement is more complicated. Spain reports rebound effects and higher water use from irrigation efficiency measures, Italy maintains conditionality on water authorisation but lacks binding irrigation and water-use restrictions at basin-level, and Greece's RBMPs set water abstraction limits but finds implementation constrained by gaps in metering and coordination between water authorities.

- Coordination between the MS's respective water authorities and the CAP implementation remains insufficient. E.g. with regard to SMR1, there is a monitoring system in the Bologna region involving all water resource management bodies, but there are no direct restrictions on farmers' water use. The same constraint was mentioned in Greece (source: Focus group 3 and 4)⁷⁴.
- The governance of water resources is highly context-specific, shaped by history, long-standing institutions, and regional traditions (some associations existed for over a century). These local governance structures play a key role in water management decisions, particularly at the intersection of agriculture and water policy⁷⁵.

Shortcomings in the use of other funds

- The **RRF** plays a pivotal role in the modernisation of irrigation infrastructure in Italy and Spain. The RRF formally applies the "**Do No Significant Harm**" (**DNSH**) principle. In theory, the RRF should only support modernisation and no new infrastructure. According to interviews with the banking sector, expansion investments are still being implemented, but information on their alignment with the principles of the WFD and RBMP is lacking.

RRF Rules: Focus on DNSH (Do No Significant Harm)

The RRF does not replicate CAP rules on irrigation efficiency (e.g. CAP conditionality or CAP's specific water savings requirements under rural development measures and sectoral interventions). Instead, RRF requires a **DNSH assessment** for each measure of their RRP under Article 17 of the Taxonomy Regulation. This could partly be because the RRF came into force before the 2023-2027 programming period.

- Under the RRF, MSs need to put forward coherent packages of measures, including both reforms/investments (in accordance w/ Article 14(1) of the RRF Regulation).

⁷⁴ In Greece, River Basin Management Plans (RBMPs) specify a maximum water abstraction limit for farmers, which are reviewed every five years to check for overuse. Fines may be imposed if farmers exceed these limits, but some lack water meters, making monitoring incomplete. Additionally, the agency responsible for water permits does not coordinate with agricultural authorities managing grants, so penalties for over-abstraction do not impact subsidy allocation.

⁷⁵ A comprehensive analysis of these governance systems across Member States lies beyond the scope of this study.

- Complying with the applicable EU & national environmental law is a separate obligation and does not waive need for a DNSH assessment.
 - “An activity is considered to do significant harm to the sustainable use and protection of water and marine resources if it is detrimental to the good status or the good ecological potential of bodies of water, including surface water and groundwater, or to the good environmental status of marine waters.” ⁷⁶
 - The measure invests in existing & in-use systems (not new abstractions). It focuses on efficiency improvements and reuse of reclaimed water. It is combined with support for sustainable agricultural practices (crop switching, natural retention measures).
- The integration of CAP support and the WFD (and RBMPs) is constrained notably for the following reasons:

RBMP3 depends heavily on national/regional legislation, which is implemented in highly variable ways across MS and regions⁷⁷. This heterogeneous implementation of the WFD leads to good alignment in some MS, while others face significant gaps. Water-saving and abstraction monitoring requirements, which are prerequisites for CAP support for irrigation investments in water bodies not in a good status, are applied differently across MS and regions, depending on the enforcement of legal frameworks. The application of these requirements is strong in some MS, but incomplete or poorly enforced in others⁷⁸.

- Example: Groundwater abstraction

Groundwater abstraction through wells and boreholes remains a common individual response notably of farmers, to water scarcity in some MS and regions. This is the most frequent action reported by farmers to secure additional water resources in MS/regions where this is allowed.

- Water abstraction from private wells is not systematically monitored and is subject to national and regional legislation.

In Germany, according to interviews with regional water management authorities⁷⁹, they reported the following that surface water abstraction is not monitored. However, groundwater abstraction is regulated, even for private wells but for extraction volumes of over 10 000m³;

⁷⁶ The JRC notes that DNSH under the RRF, based on Article 17 of the Taxonomy Regulation, aligns conceptually with WFD objectives by covering deterioration of surface and groundwater status, while setting additional requirements beyond simply meeting existing EU and national environmental law. However, integration is recent, no ex-post evaluation exists, and challenges, such as divergence in implementation, legal and technical complexity, and uneven MS capacity, may affect consistency and robustness. Source: Beltrán Miralles et al. (2023). The implementation of the “Do No Significant Harm” principle in selected EU instruments.

77 REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT on the implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC) Third river basin management plans. Brussels, 4.2.2025 COM(2025) 2 final

78 REPORT FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT on the implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC) Third river basin management plans. Brussels, 4.2.2025 COM(2025) 2 final

79 Interview with Water Management Authorities in Rhineland-Palatinate.

- In Italy, extraction from private wells is not monitored (Focus group 3).
- According to the European Commission, MS consider that the registration and monitoring of water abstraction from private wells involve too much bureaucracy.

2.7.4 Addressing gaps and shortcomings regarding water resilience at regional/local levels

Through the CAP

The links between the CAP regulations (Regulation (EU) 2021/2115 and Regulation (EU) 2022/126) and specific requirements for quantitative water management in the WFD (and third RBMPs) have been made explicit. This ensures better coherence between the CAP, water management, and CCA needs. The current challenge is to ensure that these improved rules are effectively implemented.

Through other means

To build increased water resilience, strategies are needed that combine short-term protection with long-term resilience building. This requires:

- Multilevel strategies that consider the challenges faced by diverse sectors and stakeholders, with comprehensive engagement bringing together both water and agriculture actors. The PTGE (projet de territoire pour la gestion de l'eau) initiatives launched in France offer a promising example of integrated water resource management. These projects aim to bring together all relevant stakeholders to collaboratively forecast water usage needs by 2050 while exploring various agricultural scenarios and assessing their associated socio-economic impacts. This long-term, river basin-level approach, which involves multiple stakeholders, helps anticipate systemic risks and supports more resilient and adaptive planning.
- Ensure enforcement of existing legal frameworks at the river basin level to limit water abstraction in water bodies in less than good status.
- Foster common interpretation of Article 74 and the consideration of good status of water from a quantitative aspect
- Applying quantitative water management requirements included in the WFD (and RBMPs) and referenced in Regulation (EU) 2021/2115. Regarding RBMP, developing water use indicators and robust statistics at EU, national, and river basin levels to improve water management. The Water Exploitation Index (WEI) compares total water demand (across agriculture, industry, households, etc.) to available renewable water resources. Basins with a WEI above 40% are considered to be overexploiting their water resources. In such regions, introducing

additional water-intensive activities like irrigation should be avoided (Sonderman & al.2022).

- Ensure that the application of the WFD prevents rebound effects; this could be supported using the WEI.
- Other important funding instruments, such as the RRF should be implemented explicitly in application of the WFD. This could be done as in the current CAP with explicit links between potential support and the good status of water bodies as stated in the WFD.
- Strengthen the link of Horizon Mission for Climate adaptation with the EIP AGRI. Emphasise the need to design tools through programmes such as Horizon to elaborate individual, targeted diagnoses to accompany farmers in their transition.

3 Conclusions

This study provides an integrated assessment of CCA in EU agriculture, with a particular focus on water-related climate impacts. Drawing on a diverse evidence base including an inventory of several hundred adaptation practices, farmer and stakeholder surveys, case studies across multiple MS, interviews, discussions and analysis of CAP and other policy instruments the report offers a comprehensive view of both the state of adaptation and the opportunities for strengthening water resilience.

3.1 Overall state of adaptation in EU agriculture

The evidence indicates that adaptation in EU agriculture is progressing, but unevenly and highly dependent on local climatic, hydrological and economic conditions. Across the EU, farmers, producer organisations, cooperatives, public bodies and research institutes have implemented a wide range of strategies, tools and changes in farming practices. These include the adoption of drought-tolerant crop varieties, adjustments to sowing dates, changes in livestock breeds and feeding systems, soil-building practices, landscape interventions and a growing number of water-related measures.

However, the study finds that these efforts do not always translate into increased long-term resilience. While many adaptations reduce immediate climate risks, some may inadvertently shift vulnerabilities, create new externalities. Analysis of suitability and maladaptation risks shows that interventions must be assessed in relation to system-level interactions, market conditions, supply-chain capabilities and longer-term environmental impacts, particularly where water resources are concerned.

3.2 Determinants of suitability and risk of maladaptation

The study identifies a set of factors that influence the suitability of adaptive strategies and farming practices. Effective adaptation depends on the capacity of actions to reduce vulnerability or exposure, while maladaptation occurs when unintended consequences increase vulnerability, shift risk to other groups or erode sustainable development

The findings emphasise that suitability is context-specific and shaped by:

- Biophysical and hydrological constraints, including soil conditions, water availability and exposure to extreme weather events.

- Economic and market factors, particularly the feasibility of marketing new products arising from adaptation (e.g. new drought-tolerant crops), and the capacity of supply chains to absorb such changes.
- Policy incentives, notably the extent to which CAP instruments align with adaptation needs.
- Risk of rebound effects, such as increased groundwater extraction in response to drought, which can intensify pressure on shared aquifers and shift vulnerabilities to neighbouring farms and ecosystems.
- Uncertainty about future climate impacts, which requires adaptive monitoring and continuous adjustment.
- Overall, the report concludes that suitability assessment must be embedded in multi-level governance frameworks that consider cumulative impacts at farm, landscape and river-basin scales.

3.3 Drivers and barriers influencing farmers' decisions to adapt

Farmers' adaptation decisions are shaped by a complex mix of economic, cognitive, social and institutional factors. Survey and case study evidence reveals that:

- Key drivers include direct experience with extreme weather, long-term business considerations, advisory support, peer learning and the availability of technology and information tools (e.g. digital irrigation advice, early-warning systems).
- Barriers are often concentrated in the categories of 'meaning and sense', 'material aspects' and 'social norms'. The most significant barriers include limited margins to self-finance adaptation investments, perceived misalignment of adaptation actions with farm identity or vision, and uncertainty about long-term benefits

3.4 Costs and benefits of adaptation

The analysis of costs and benefits highlights substantial variation across adaptation types, sectors and scales. At farm level, many adaptations have mixed economic outcomes, reflecting differences in capital requirements, operational costs, expected yield impacts and time horizons. At EU level, benefits include avoided climate damages, improved soil health, reduced water demand and enhanced long-term resilience, though quantifying these consistently remains challenging.

Cost-benefit evidence shows that practices such as improved irrigation efficiency, soil organic matter enhancement, agroforestry, crop diversification

and specific animal-welfare strategies can deliver multi-dimensional benefits, but their economic feasibility is highly dependent on regional climatic and market conditions

3.5 Water Resilience: challenges and opportunities

In relation to water-related climate impacts the evidence confirms that water scarcity, droughts and heavy rainfall events are intensifying across the EU, with Southern Europe experiencing the strongest upward trend in agricultural water abstraction since 2010. A wide variety of water-related adaptation practices have been identified, but uptake varies significantly between Member States. Measures to reduce water demand including switching to lower-water-use crops, improving soil structure and adopting rainfed systems are promising but often insufficient on their own to ensure long-term resilience.

Infrastructure-based measures, such as irrigation modernisation and water storage, are widely supported through CAP interventions, particularly in Mediterranean countries. However, these measures must be carefully designed to avoid maladaptation, especially where they risk encouraging expanded irrigated areas or increasing pressure on groundwater resources.

Crucially, the study finds that water resilience requires coordinated, river basin-scale governance mechanisms, data-driven water allocation frameworks and a shift towards water-saving cultures across agricultural and non-agricultural users. Without such system-level alignment, farm-level adaptations may have limited or counterproductive impacts.

3.6 Policy response

A diversity of CAP instruments support CCA in agriculture. Enhanced conditionality plays a key role in promoting sustainable soil management and soil health, combating erosion, and supporting water retention capacity in soils. It applies de facto to all CAP beneficiaries of area- and animal-based payments. The CAP further promotes farming practices identified by the JRC as supporting adaptation to CC through voluntary eco-schemes and AECC at the parcel level. These practices may be further reinforced by green (productive and non-productive) investments, to which farming practices have also been linked⁸⁰. Sectoral interventions particularly support CCA through the introduction of new varieties, pest control, and other related farming practices. Finally, cooperation

⁸⁰ The green investment does not cover the development of new irrigation infrastructure. Information on investment support for new irrigation infrastructure is not available, as it is reported under the general category of investment support (article 73 and article 74 are reported together). Support for the modernisation of existing irrigation infrastructure is captured under the farming practices W14X and W15X; however, these categories are broader and also include other types of investments, such as energy.

measures (Articles 77 and 78 of the CAP, including operational groups under EIP-AGRI, LAGs, and other cooperation support), although modest in financial terms and underutilised for CCA, help foster bottom-up responses to local climate impacts.

Other policy instruments (Horizon, LIFE, RRF, EIB, WFD) support directly or indirectly adaptation in EU agriculture. They present varying degrees of coordination with the CAP to address climate impact drivers in the different EU biogeographical regions. The EIP-AGRI plays a pivotal role in creating synergies with Horizon and recently with LIFE. Horizon significantly supports CCA in agriculture through an interactive process involving farmers and multi-actor engagement (see SQ6.1-6.2⁸¹). The EIB is increasing its financing towards EU agriculture and adaptation thereby providing great potential to foster adaptation of farms.

Despite the diversity of CAP and other policy instruments supporting CCA, gaps remain. There is a lack of a clear, shared understanding of what CCA entails, due to the multi-dimensional and context-dependent nature of adaptation in response to diverse climate risks across EU territories, sectors, and production systems. Moreover, comprehensive stakeholder involvement in a given area or sector is often missing in the elaboration of strategies, as well as the visualisation of future climate scenarios, especially when it comes to water resilience in water scarce territories.

A shared understanding of adaptation is needed to guide the elaboration of long-term strategies at different levels (regional, territorial, and local) and for various actors (public and private). Enhanced collaboration between EIP-AGRI, the EU Mission on Climate Adaptation (Horizon), and other Horizon tools would facilitate the effective transfer and scaling up of climate adaptation practices.

The coherence between the WFD and the CAP was strengthened for the 2023–2027 period. Safeguards were introduced to prevent support for the expansion of irrigation in water-scarce areas by explicitly linking investment support for irrigation to the requirements of the WFD. The study identified good examples of integration in several Member States. However, in Member States facing water scarcity in the Mediterranean biogeographical region, the effective implementation by water authorities, the interpretation of the effects of investments on the good status of water bodies, and the enforcement of environmental legislation—especially the WFD—is uneven.

Many tools are available to support individual farming practices, but fewer tools exist to address water-resilience beyond farm level, at landscape level, through appropriate local strategies.

⁸¹ SQ6.2 identified 3 advisory networks, 3 thematic networks and one living lab as relevant to CCA for Horizon2020. For Horizon Europe, this concerns 14 living labs and 2 thematic networks.

Comprehensive stakeholder engagement, including the private sector operating in the relevant areas, is needed in the development of local strategies. Horizon has the potential to further support adaptation in EU agriculture by facilitating not only the testing of solutions but also the development of longer-term strategies and the design of tools to assist farmers in their adaptation efforts through specific calls on the topic. EIP-AGRI and AKIS play a pivotal role in the dissemination of information and can be leveraged to foster a shared understanding of adaptation in agriculture among stakeholders. In addition, specific guidance on what water resilience in agriculture entail is needed for the EIB to ensure that sustainable investments are well-targeted.

4 Lessons Learned

The evidence collected across the report points to several overarching lessons regarding climate adaptation and water resilience in EU agriculture.

4.1 Lesson 1: Short-term risk management strategies must be complemented with a stronger focus on transformative long-term resilience building measures

Evidence suggests that many adaptation actions implemented on farms respond to climate pressures through incremental changes in practice such as stockpiling fodder reserves for low-yielding years, timing phenological development so that crop development coincides with the most favourable conditions or adapting irrigation based on the wind conditions. These measures contribute to reducing short-term vulnerability to climatic hazards, but incremental and reactive practices alone do not necessarily build structural resilience. In some instances, other measures that appear beneficial such as investing in more efficient irrigation infrastructure or damage-related insurance can fail to address the root cause of vulnerability and even lead to maladaptive outcomes without strict rules or regulation. A key finding is that robust adaptation strategies require integrating short-term operational measures with investments in long-term resilience, such as soil regeneration, diversification of production and systems, landscape-scale nature-based solutions and reduction in water consumption.

4.2 Lesson 2: Water resilience relies on coordinated, river basin-level governance and cannot be secured solely through farm-level measures

Water scarcity, drought and increasing climatic variability place agriculture under intensifying pressure. A wide range of water-related practices has emerged at farm level such as irrigation efficiency technologies, water storage, water retention in soils and selection of crops with lower water requirements. Yet the analysis shows that the effectiveness of these measures is ultimately shaped by broader hydrological and governance conditions. Irrigation modernisation and water infrastructure investments are widely supported across Member States, but their long-term contribution to resilience depends heavily on how water allocation is regulated, monitored and enforced. In areas where water governance frameworks are weak or where water efficiency savings lead to expansion of irrigated areas, this may inadvertently increase total abstraction, undermining collective resilience.

The evidence consistently indicates that sustainable water resilience requires full compliance with the WFD, coordinated river basin-level management, transparent allocation rules, improved data on water availability and use, and collaboration among agricultural, water and environmental authorities. Farm-level technological improvements are necessary but insufficient on their own.

4.3 Lesson 3: Effective adaptation depends on addressing economic, cognitive and institutional barriers simultaneously

Across Member States, farmers' adaptation behaviour is shaped by a combination of economic feasibility, perceptions of risks and opportunities, access to knowledge and advisory services, and prevailing social norms. Many farmers identify uncertain financial returns and long-term benefits of adaptation as key constraints, particularly where measures require upfront investment or involve operational changes that may initially reduce yields or increase complexity.

At the same time, the analysis shows that knowledge gaps, limited advisory capacity, and hesitancy to adopt unfamiliar practices influence uptake. Even economically viable options may not be taken up if they conflict with farm identity, require new technical capabilities or are not supported by trusted information channels.

Taken together, the evidence suggests that adaptation support must be multidimensional combining economic incentives, advisory and technical services, peer learning mechanisms and risk-management tools. Interventions that focus on only one type of barrier are unlikely to shift behaviour at scale.

4.4 Lesson 4: Assessing the suitability of adaptation options requires attention to system interactions and potential unintended consequences

Across farming systems, adaptation measures interact with environmental processes, market structures and social dynamics in ways that can produce outcomes beyond their intended effects. For example:

- Changes in crop choice may reduce water use but increase soil erosion or create market risks if supply chains cannot absorb new products.
- Efficiency gains in irrigation systems can reduce per-hectare water use but may contribute to increased overall abstraction if water savings are reallocated to new production areas or more water-demanding crops.

- Soil management practices can contribute to water retention and soil health but require sustained, long-term implementation before benefits become fully observable.

The evidence underscores that suitability assessments must explicitly consider broader system feedback across hydrology, soils, markets and policy frameworks rather than focusing solely on isolated technical performance at farm level.

4.5 Lesson 5: Coherent implementation of policy is a prerequisite for effective and scalable adaptation

The WFD establishes rules for water quality and quantity in Europe, aiming to ensure good status for rivers, lakes, and groundwater, based on a river basin district approach and implemented through RBMPs. The analysis of Member State interventions shows that the CAP provides extensive support for practices relevant to adaptation, including soil cover, crop diversification, precision farming and irrigation improvements. The degree of coordination or integration across instruments varies. While the coherence between the CAP and the WFD was reinforced, its effective implementation varies across water authorities. For example, investments in irrigation infrastructure or modernisation can have limited resilience benefits if not aligned with broader water-allocation rules, monitoring systems and environmental objectives.

This requires not only integration in implementation of but coordination across all stakeholders delivering CCA. To this end, there should be a common understanding of the case for CCA among all relevant stakeholders and greater engagement from the private sector to drive and support change at industry level. The evidence highlights the importance of integrated policy frameworks that align agricultural support with water management, climate objectives, and spatial planning to avoid contradictory incentives and to reinforce long-term resilience pathways. Integration and coordination of delivery will also be key.

4.6 Lesson 6: Improved monitoring, data and evaluation systems are foundational for adaptive management

Across the report, gaps in data emerge as a significant constraint for evidence-based adaptation. These include limited information on water abstraction for agriculture, partial or inconsistent data on uptake of adaptation practices, and weak linkages between policy support and environmental outcomes. These gaps hinder strategic planning, early identification of maladaptation risks and systematic assessment of policy effectiveness. They also limit the ability of farmers, advisers and authorities to make informed, timely decisions in response to evolving climate risks.

Strengthening monitoring systems through harmonised indicators, improved water accounting, and regular reporting on adaptation uptake and outcomes is essential to support adaptive management and effective policymaking across scales.

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