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Sustainable management of natural resources with a focus on water and agriculture

Study - Final Report

Science and Technology Options Assessment

STOA

Sustainable management of natural resources with a focus on water and agriculture

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AUTHORS

Jana Poláková, Project Leader, IEEP
Andrew Farmer, IEEP
Sandra Berman, BIO Intelligence Service
Sandra Naumann, Ecologic Institute
Ana Frelih-Larsen, Ecologic Institute
Johanna von Toggenburg, Ecologic Institut

RESPONSIBLE ADMINISTRATOR

Lieve Van Woensel
Science and Technology Options Assessment (STOA)
Directorate for Impact Assessment and European Added Value
DG Internal Policies
European Parliament
Rue Wiertz 60 - RMD 00J012
B-1047 Brussels
E-mail: lieve.vanwoensel@ep.europa.eu

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Abstract

Water is a key natural resource targeted within resource efficiency policy of the European Union, as well as globally. This study has focussed on research, technologies and options for sustainable water use and water efficiency; agricultural land management with soil and water benefits; and measures within the Common Agricultural Policy (CAP) to address sustainable management of water and soil resources. Six key areas for improvement have been identified:

(1) The legislative framework currently in place to protect Europe's waters needs to be implemented fully and effectively as well as adequately enforced;

(2) Water priorities that have been articulated at the EU level need to be more fully integrated and well implemented within the sectoral policies at EU, national and regional levels;

(3) Water losses should be reduced and water savings and efficiency should be increased, in particular in agriculture and water scarce areas;

(4) Land and soil management approaches aimed at combating soil erosion, preventing loss of soil organic matter, sequestering soil carbon and improving water retention are critical for long-term sustainability of farming and healthy ecosystems and should be promoted at all levels;

(5) EU funds, including CAP, allocated to water priorities should be used in an efficient and effective way; and (6) improved data and decision support tools relating to water and soils are essential for making informed decisions that support sustainable management of water and soil.

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Corresponding author: Jana Poláková, IEEP (Jpolakova@ieep.eu).

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Henk Westhoek and Koen Overmars (PBL Netherlands)
Catalina Radu (National Institute of Hydrology and Water Management, Romania)
Lars O. Hansen and Thomas F. Mortensen (Ministry of Food, Agriculture and Fisheries, Denmark)
Nigel Boatman (Food and Environment Research Agency, Defra, UK)
Peter Kristensen (EEA)
Renée L'Herr and Krzysztof Sulima (European Commission, DG Agriculture)
Ville Keskisarja (Ministry of Agriculture and Forestry, Finland)

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ACRONYMS

List of Abbreviations

CAP	Common Agricultural Policy
CMEF	Common Monitoring and Evaluation Framework
Defra	Department for Environment, Food and Rural Affairs
DMP	Drought Management plan
DSIRR	Decision Support for Irrigated Agriculture
EAFRD	European Agricultural Fund for Rural Development
EIP	European Innovation Partnerships
ENRD	European Network for Rural Development
EC	European Commission
ECA	European Court of Auditors
EEA	European Environment Agency
EPI	Economic policy instruments
EU	European Union
EU-27	All 27 Member States of the European Union.
FAO	Food and Agricultural Organization of United Nations
FAS	Farm Advisory System
GAEC	Good Agriculture and Environmental Condition
GIS	Geographic Information System
GMES	Global Monitoring for Environment and Security
ICT	Information and Communication Technologies
JRC	Joint Research Centre
IPARD	Instrument for Pre-Accession Rural Development
IRRINET	Global Monitoring for Environment and Security
IWRM	Main research projects on integrated water resource management
LIFE+	EU Financial Instrument for the Environment
MS	Member State
RBMP	River Basin Management Plan
RDPs	Rural Development Programmes
SIAR	Irrigation Advisory Service for Farmers
SIRIUS	Sustainable Irrigation water management and River-basin governance: Implementing User-driven Services
SMRs	Statutory Management Requirements
RDPs	Rural Development Programmes
UK	United Kingdom
WHO	World Health Organisation

EXECUTIVE SUMMARY

Water is a key natural resource targeted within resource efficiency policy of the European Union, as well as within the global policy frameworks of the UN. The purpose of this study is to provide an overview of issues in the management of water as a natural resource in the EU and the management of natural resources linked to EU agriculture, as well as recommending policy options. The study focuses on three areas:

- **Sustainable water use and water efficiency**, while highlighting issues linked to agriculture and rural areas;
- **Agricultural land management with soil and water benefits**; and
- **CAP measures** to address sustainable management of water resources, including water quality, regular water flows, water use and sustainable soil management.

The geographic scope of the study is the EU-27. Exceptionally, relevant examples from outside the EU are presented. The diversity of conditions across the EU has been taken into account, including different bio-physical, environmental, climatic and farming conditions. Evidence draws on a wide range of secondary sources, including scientific literature, evaluation studies and available case studies. No new empirical data have been generated.

The importance of sustaining EU water resources

Water plays an important role in the sustainable use of resources, including water quality and quantity. Climate change is expected to exacerbate further pressures such as more frequent and more severe droughts and floods, requiring adaptation by both water users and Member States. While the issues are often different in each Member State or even river basin, reducing the pressure on water resources is important throughout the EU as it may have consequences upstream and downstream, and have associated benefits for ecosystems (eg on biodiversity), economy (eg on reducing energy used for water pumping and treatment) and climate stability (eg on GHG emissions linked to energy use). Given that over 40 per cent of Europe's total area is under agricultural use, land management is critically important for maintaining the natural resource base, including water. Agricultural practices affect:

- Water availability through their use of water for irrigation, animal husbandry, on-farm processing etc;
- Water quality through diffuse pollution from nutrients and pesticides;
- Water flows in river basins by drainage and irrigation; and
- Soil functionality, with knock-on effects on water flows, water infiltration rates, and water pollution by the sediment overflow.

The recently published Blueprint to Safeguard European Water Resources proposes EU-level actions to better implement water legislation, integrate water policy objectives into other policies, and fill the gaps in particular as regards water quantity and efficiency. The EU Soil Thematic Strategy has been an important driver for awareness and development of research actions in relation to soils but with no overarching EU framework for soil management, its impact has been limited. This study therefore examines the effectiveness of the 2007-2013 CAP measures in addressing sustainable management of water and soil resources. While the next programming period will see significant changes in the CAP, the proposed post 2014 policies have not been finalised and are therefore not analysed in detail.

Sustainable water use and water efficiency

Water resources include surface and groundwater sources ('blue water'); rainfall (called 'green water'); and recycled wastewater ('grey water'). According to EEA, in Europe as a whole, 37 per cent of the freshwater abstracted is used for cooling in energy production, followed by agriculture, 33 per cent; public water supply, 20 per cent; and industry, 10 per cent (note that in some cases considerable quantities of abstracted water are returned to water bodies). Whether or not water shortages occur is an issue depending on geographic location, season and demand for water. However, reducing the pressure on water as a resource can be considered of importance across the whole of the EU due to up and downstream consequences as well as associated impacts. This study therefore addresses the role of scientific research, technologies and good practices, including water pricing in reducing water use and improving water efficiency.

EU research and innovation on improved water use plays a fundamental role in meeting future water challenges. On-going research initiatives that address water resources under EU FP7 projects and in the Commission's JRC focus for example on better water management schemes and efficient techniques, sustainable land and soil management with water benefits, integrated water resources management including stakeholder cooperation, and economic policy instruments linked to water resources. The study identifies important research gaps in the area of water quantity, including the calculation of ecological flows. Significant research efforts are under way to support sustainable and efficient use of water. Other research needs relate to specific aspects of water availability, soil functionality and water quality.

Within the area of **innovative technologies and options for improved water use and efficiency**, there are a range of options including technological and non-technological options. The types of technologies and options investigated include: monitoring of water use, alternative water sourcing such as rainwater harvesting and on-farm storage, agricultural land management practices, and conveyance technologies such as canal lining to reduce leaks. Other technologies that can be useful are rating tools and standards, precision irrigation techniques, and decision-making support tools for water savings. In the implementation of all such technologies, it is important to consider their relevance to local conditions and to different users, and in agricultural land management options, their relevance to soil, crop and climatic conditions. For innovations aimed at water efficiency, it must be ensured that they do not lead to increase in water use. Moreover, any negative effects on soils and biodiversity, such as may occur in applying canal lining, must be seriously assessed before any such innovation is implemented.

Within the area of **good policy practices on sustainable water use**, relevant examples focus on agriculture, urban areas, and the links between them, and can be found at national or river basin levels. Policy practices are distinguished here from technical actions, while recognising that a policy might be the strategic implementation or support for these actions.

Examples of good policy practices relating to agricultural water management include the agri-environment measure under CAP Pillar 2, and other instruments such as water trading and irrigation advisory services. In urban water management, good policy practices aim at overcoming challenges to inefficient water supply and reducing leakage levels, improving efficiency of water use in buildings and increasing resilience to floods, etc. Successful examples exist for all of them, at national level. Policies on wastewater re-use can be useful to regulate the use of wastewater from agricultural use (eg from washing machinery), or from urban wastewater systems, for certain agricultural activities such as irrigation. However, standards and regulations on sanitary issues are not aligned at an EU level and issues remain in public acceptance.

The introduction of incentives to water pricing is another policy option that could reduce water use. It would be complementary to the WFD principle that requires cost recovery for water services. A range of pricing mechanisms exist, including tariffs and charges, taxes and tradable permit schemes. Tariffs in agriculture are generally based on the area irrigated, the type of crop, a combination of the two, and/or a volumetric component, but many possibilities exist. If a volumetric component is used, then metering is required. However, metering devices, especially in agriculture, are often lacking and their installation requires good financial planning. Water pricing may be a strong tool for increasing resource efficiency, when used alongside other incentives for water efficiency, and in a well designed mix of instruments. However, issues of affordability to low-income users, social equity, public acceptance, and the risk of illegal abstractions must be taken into account before a pricing policy is developed.

On the basis of assessments relating to sustainable water use and water efficiency, the study recommends several priority options:

- Enforce water policies fully at national level;
- Better integrate water priorities into agricultural and energy policies; use climate- and biodiversity-proofing of river basin management measures;
- Reduce water losses, increase water savings and efficiency through technological options including water metering and water re-use, and non-technological options;
- Improve decision-making through the provision of better information and improve water allocation rules; and

Ensure effective use of EU funds aimed at improvements in water infrastructure.

Agricultural land management with soil and water benefits

Soil management can be targeted to benefit soil protection and its fertility as well as water availability and quality. It often has co-benefits and trade-offs with other environmental priorities including climate change mitigation and adaptation, biodiversity protection and farmers' economic objectives. Conscious prioritisation between these various benefits and tailoring to local conditions is a key success factor.

The study considers crop-related **soil management actions that directly target sustainable water use** and may save irrigation water. Such actions can focus on:

- Optimisation of crop patterns (eg by changes of the crop cycle, choice of drought tolerant species or varieties);
- Increased soil water retention (eg by tillage, mulching, application of soil improvers, weed control, fallow, intermediate crops etc); and
- Reduced crop water needs by optimal management of the leaf canopy.

In addition to crop-related soil management, there are additional measures on natural water retention. This could for example include creating buffer strips or restoring wetlands and could be applied to both farmland and wider ecosystems[1].

A range of **management actions that directly contribute to soil protection** has been reviewed in the study as a primary focus. These actions are of particular importance to adaptation to climate change; including water scarcity, droughts, extreme precipitation etc.

[1] Examined in a comprehensive study by JRC, these measures are outside the scope of the present report.

Appropriate soil management can also deliver significant mitigation benefits by preserving existing carbon stocks in agricultural soils, increasing sequestration of carbon in soils, and reducing nitrous oxide emissions associated with agricultural land use. On the other hand, poor management of soils can lead to increased GHG emissions, for example, due to fertiliser use, drainage and mineralisation of peatlands, or soil erosion and associated loss of soil organic matter. The most relevant management actions that deliver soil benefits include:

- Cropland management (such as winter cover and catch crops, crop rotations with or without legumes, crop residue management, reduced tillage);
- Grazing land management (such as optimising grazing intensity, length and timing of grazing, grassland innovation); and
- Cross-cutting actions which include land use changes and forestry (such as buffer strips, maintaining and restoring wetlands, conversion of arable land to grassland, woodland creation).

These practices can also have substantial synergies with environmental protection in general and are central to sustainable farming, including biodiversity, water quality protection and food security. They have benefits for farmers in terms of improved resource efficiency, cost savings and potentially greater economic stability.

The study recommends four priority options for sustainable soil management:

- Promoting sustainable soil management practices through appropriate policies;
- Strengthening soil management requirements in the GAEC framework and introduce an EU-wide framework for soils;
- Adopting good practices for identifying soil risks at regional and local levels across the EU; and
- Establishing routines for climate-proofing relevant regional and national programmes;

CAP measures for improved water and soil management

Water and soil issues increasingly have become a priority within the CAP over the past few decades, building on an early emphasis on landscape and biodiversity within agri-environmental measures when they were first introduced into the CAP in the 1980s. Since the 1990s, the Nitrates Directive, alongside support provided through agri-environment schemes, have been the most influential policy instruments for reducing diffuse pollution from agriculture. The Sustainable Use of Pesticides Directive and Water Framework Directive should play an increasingly important role in the coming years. Many CAP measures have the potential to deliver water and soil benefits but cross-compliance and the agri-environment measure are the two that are most critical for ensuring these benefits. The CAP reform offers opportunities to improve the delivery of soil and water. Whether or not policy measures are effective depends on the actual outcomes achieved for water and soil on the ground, which in turn depends on the way that these measures are designed and implemented by Member States. Whilst many concrete examples exist of promising measures and schemes, the data tend to be prospective in nature, highlighting anticipated impacts rather than actual results. Information on the actual environmental impacts exists mostly in relation to a few Pillar 2 measures; no data exist on the impacts of cross-compliance.

Agri-environment measure: Many Member States have used the measure to encourage land management that is tailored and targeted to the particular combination of water and soil needs. Due to the importance of this measure in encouraging sustainable land management practices, it is the only compulsory measure within Pillar 2 and in some Member States accounts for a considerable proportion of the overall rural development budget. In the 2007-2013 programming period, more than half of the RDPs directly targeted water quality in their agri-environment schemes[2]. Actions include input reduction to decrease nutrient and pesticide run-off, or the establishment and maintenance of riparian buffer strips and field margins. Actual improvements in water quality may take a long time to be visible (up to 40 years) so it is difficult to ascertain the resulting water impacts. Agri-environment measures that support the maintenance and creation of wetlands have the potential to enhance the management of water flows; for example, to increase low flows, and to filter nitrate run-off. A number of Member States have implemented such wetland schemes. Only a few agri-environment schemes have targeted water availability, due to the fact that water availability is more frequently addressed by capital investments.

Pillar 2 infrastructure investments have been used for water quality benefits through improved livestock housing, manure storage, manure and silage handling and processing investments for activities to increase water use efficiency. In one third of the 2007-2013 RDPs, including those for the Mediterranean regions, capital investments have been used to support improved irrigation technology. However, whether or not such grants deliver net water savings in practice is ambiguous. Several Member States used investment grants to support actions involving the maintenance of drainage, re-use of drainage water and in some cases, the establishment of controlled drainage. There needs to be improved understanding of the actual environmental outcomes achieved, but evaluations are lacking to date.

Cross compliance: A certain level of management is required as a condition both for receipt of direct payments and for area based agricultural payments under Pillar 2. The Statutory Management Requirement (SMR) relating to the Nitrates Directive has helped to reinforce the application of actions in nitrate vulnerable zones. Pesticide and WFD requirements have not yet been included in the list of SMRs, although this has been proposed under the current CAP reform. Only anecdotal evidence exists on soil and water impacts of the standards of Good Agricultural and Environmental Condition – GAEC. The evidence that does exist suggests that, to date, their impact has been weak in relation to reducing soil erosion and maintaining soil organic matter. In situations where markets forces are driving increased production in arable areas, the GAEC standards are often not demanding enough to ensure that the resources of soils and water are maintained above sustainable thresholds. A pan-European level evaluation of cross-compliance is urgently needed.

Other funding measures outside the CAP: Measures exist at EU level (LIFE+), and at national level, eg voluntary approaches, certification schemes, PES schemes, financial instruments including loans and market based approaches. All these measures could be used for improving the delivery of soil and water benefits and complement constrained CAP funds after 2014.

The study recommends five priority options for incentivising improved soil and water management through the CAP:

- Ensure that CAP cross-compliance requirements relating to water and GAEC standards relating to soil are strengthened and appropriately enforced;
- Use RDP funds for capital investments only when significant benefits for water and soils are demonstrated; use stringent safeguards and eligibility requirements for water savings;
- Use RDP funds for land management only when significant benefits for water and soils are demonstrated or in priority areas; avoid double funding;
- Strengthen the effectiveness of monitoring and evaluation in relation to soils and water, by setting clear objectives and associated criteria for measuring success; and

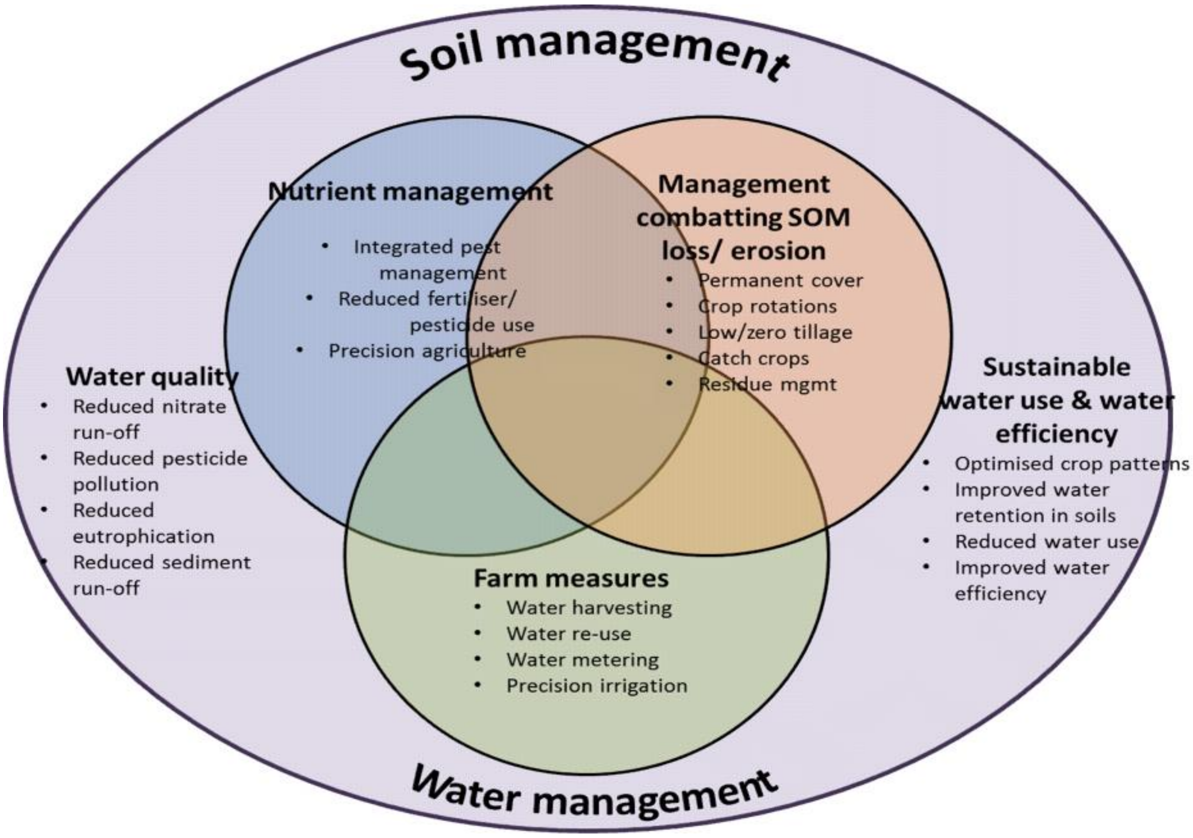
[2] Indicative information is based on data from 2009, which are now to some extent outdated.

- Ensure that the 2017 and 2019 enhanced CAP reporting demonstrates the outcomes of Pillar 1 greening measures and RDP support for water and soils.

Conclusions

This study has found that a major change is needed in approaches to water use and water efficiency in all sectors, and in approaches to sustainable soil and water management in agriculture, to meet EU targets for good water conservation status. A range of technologies, policy practices, and land management approaches to water and soil protection have been identified. These may sometimes represent a public good, but not in all cases. Depending on the level of environment benefits provided, the technologies and practices could represent a mere compliance with the polluter pays principle, could ensure a private good through maintaining soil productivity or water efficiency to businesses and farms, or could provide significant water and soil benefits that represent valuable public goods. Potential win-wins for sustainable soil and water outcomes through improved land and farm management are illustrated in Figure 1.

Figure 1: Potential sustainable soil and water outcomes through improved land and farm management



Six key areas for improvement have been identified in this study:

- The legislative framework currently in place to protect Europe's waters needs to be implemented fully and effectively as well as adequately enforced;
- Water priorities that have been articulated at the EU level need to be more fully integrated and well implemented within the sectoral policies at EU, national and regional levels;
- Water losses should be reduced and water savings and efficiency should be increased, in particular in agriculture and water scarce areas;
- Land and soil management approaches aimed at combating soil erosion, preventing loss of soil organic matter, sequestering soil carbon and improving water retention are critical for long-term sustainability of farming and healthy ecosystems. The CAP should play a role in promoting these approaches, but farmers and national and regional administrations should also initiate action; and
- EU funds and CAP funds allocated to water priorities should be used in an efficient and effective way.

OPTIONS BRIEF

Water is a key natural resource targeted within the resource efficiency policy of the European Union, as well as within the global policy frameworks of the UN. Both water quality and water quantity play an important role in the sustainable management of this natural resource. Agriculture is dependent on many natural resources one of which is water. Climate change is expected to exacerbate existing pressures on both water and the agricultural sector, such as more frequent and more severe droughts and floods, affecting agricultural soils, and requiring adaptation by water users, farms, regions and Member States. Against evidence of pressures on water in the EU, this study has developed recommendations focussing on:

- **Sustainable water use and water efficiency**, while highlighting issues linked to agriculture and other sectors;
- **Agricultural land management with soil and water benefits**;
- **Measures within the Common Agricultural Policy (CAP)** to address sustainable management of water resources, including **water quality, water use, regular water flows and sustainable management of soils.**

This brief highlights recommended priority options in these areas. These options promote the EU's goals to achieve good ecological and chemical water status and improved performance of the agricultural sector, alongside other sectors. At the same time, the options aim to ensure that European agriculture maintains its natural resource base to be able to continue producing food in the future. Six key areas for improvement have been identified:

- **The legislative framework** currently in place to protect Europe's waters needs to be implemented fully and effectively as well as adequately enforced.
- **Water priorities that have been articulated at the EU level need to be more fully integrated** and well implemented within the sectoral policies at EU, national and regional levels.
- **Water losses should be reduced and water savings and efficiency should be increased,** in particular in agriculture and water scarce areas.
- **Land and soil management approaches aimed at combating soil erosion, preventing loss of soil organic matter, sequestering soil carbon and improving water retention** are critical for long-term sustainability of farming and healthy ecosystems. The CAP should play a role in promoting these approaches, but farmers and national and regional administrations should also initiate action.
- **EU funds, including CAP funds, allocated to water priorities should be used in an efficient and effective way.**
- **Improved data and decision support tools relating to water and soils** are essential for making informed decisions that support sustainable management of water and soil.

To make progress in these key areas, the following priority options should be addressed.

A. Options for sustainable water use and improved water efficiency

Fully implement and enforce regulations at national and local level

The body of existing water policies at EU level addresses the majority of relevant issues that impact on water use and water efficiency. The Water Framework Directive (WFD) is an overarching policy instrument that should drive improvements across the EU. Better enforcement and implementation of the whole regulatory framework is essential for reducing negative impacts on water, including impacts from agriculture. Stopping illegal water abstraction is one of the key improvements needed.

Better integrate water priorities into agricultural and energy policies; climate- and biodiversity-proof river basin management measures

Water priorities that have been articulated at the EU level need to be more fully integrated into and well implemented through sectoral policies at EU, national and regional levels. Energy and agriculture are major users of water and impact water quality, therefore, within these sectoral policies negative incentives should be reduced and water issues addressed. Safeguards should be introduced into bioenergy policies so that biomass cultivation and extraction does not lead to further pressure on soils and water. ***Reduce water losses, increase water savings and efficiency.***

Several complementary approaches must be promoted. First, water savings and more efficient use of water should be achieved through water metering, improving irrigation efficiency, reducing leakages to a sustainable economic leakage level, and irrigation scheduling. In particular, water metering should be introduced and enforced via water policies, and could potentially target water scarce areas or water-intensive cropping systems. Second, improved water availability should be achieved through water re-use, rainwater harvesting and storage. EU-wide standards should be developed for water re-use. Third, improved land and soil management approaches will provide important water benefits.

Improve decision-making through the provision of better information and improve water allocation rules

Water is, to a large extent, a local issue but with cross-border dimensions and subject to change in time, so the same activity in different catchments, years or seasons may not have the same impact. Improved tools that provide information at the right scales and resolutions are necessary for policy makers, businesses and farms. Decision support tools, for example irrigation scheduling for farmers, robust methodologies for accounting for water balances and ecological flows to inform water allocation and pricing, and a thorough cost-benefit analysis including externalities, as required in the WFD should be developed and used more widely.

Ensure effective use of EU funds aimed at improvements in water infrastructure

Certain capital investments to increase water efficiency, metered water use, and water savings may merit public support under Structural and Cohesion funds, rural development, EIB loans, and LIFE+ funds. However, EU funds should be granted only for modernisations with clear additional environmental benefits over and above that which would have been achieved without the funding in place. The grants should thus comply with stringent eligibility criteria and safeguards. Several supporting options are also needed, such as research and innovation support, target-setting, guidance and information, and capacity-building.

B. Options for land management with water and soil benefits

Promote sustainable land and soil management practices through appropriate policies

Land management approaches to increase natural water retention at landscape level and soil management approaches to combat soil erosion, prevent loss of soil organic matter and sequester soil carbon should be promoted at EU, national and regional levels. Requirements for permanent vegetation cover should be applied more consistently under the GAEC – this would be highly effective in combating erosion. Second, maintaining and restoring wetlands, wet meadows and floodplains has valuable benefits for natural water retention, habitats and climate regulation, and critically depends on the CAP, LIFE+ and national funds. Other soil management actions, such as more complex crop rotations, intercropping of legumes or other N-fixing crops and reduced tillage can be promoted by agri-environment schemes where they go beyond the baseline requirements. Dissipation of large amounts of agri-environment-climate budgets on basic soil practices should be avoided.

Adopt good practices for identifying soil risks at regional and local levels across the EU

Priorities for soil management depend on identifying places where actual soil risks occur. Several approaches exist for identifying locations with soil risks, but they are not applied everywhere or sometimes inappropriate methods are used. There is a need to develop the technical capacity and tools to identify such areas, such as maps and soil inventories, incorporating local knowledge on nutrient levels and soil structure as well as scientifically validated sustainability indicators for adequate targeting of risk areas. ***Establish routines for climate-proofing relevant regional and national programmes.***

Climate-proofing regional and national programmes and strategies (for several sectors in addition to agriculture and rural development such as industry, forestry, energy, business, or tourism) is a proactive approach to assessing the potential impact of soil management on climate change mitigation and adaptation. Integrating them into the regular cycle of programming rather than creating a separate task would be a cost-efficient solution.

Several supporting options are also needed, such as streamlining, guidance, raising awareness, etc.

C. Options for improved water and soil management through the CAP measures

Ensure that CAP cross-compliance requirements relating to water and GAEC standards relating to soil are strengthened and appropriately enforced

Basic soil and water management should be better integrated into the cross-compliance requirements and more adequately enforced. There are a limited number of current GAEC requirements operating within Member States that are specifically focussed on soil organic matter (SOM). Reinforced requirements are needed in particular to maintain soils containing low SOM that are at risk of complete depletion and soils containing high SOM such as peat lands and wetlands where the risk of large carbon losses is highest. Basic actions (permanent vegetation cover, contour ploughing and buffer strips) should be more fully enforced through the GAEC framework. The Sustainable Use of Pesticides Directive should be retained in the revised list of SMRs. The GAEC standards for the protection of groundwater against pollution and protection of soil organic matter should be kept in the revised framework, as agreed in the plenary vote by the European Parliament. The WFD should be re-instated in the list of SMRs. Training and advisory services should play a role in improving farmers' knowledge of the sustainability benefits of the GAEC standards.

Use RDP funds for capital investments only when significant benefits for water and soil are demonstrated; use stringent safeguards and eligibility requirements for water savings

Funding to improve sustainable water use, water efficiency on farms, and water quality should be carefully assessed against anticipated water impacts. Often these capital investments are driven primarily by economic objectives and have low additional benefits compared to investments that would have taken place without support. Therefore, it should be ensured that only infrastructure investments with demonstrated high water savings or water quality improvements receive public support. Where upfront costs are a barrier to the capital investment into new infrastructure on farms, for example in manure storage, public support is justifiable. If approved, the eligibility requirements set out for irrigation in the proposed Rural Development Regulation will be a welcome improvement.

Use RDP funds for land management only when significant benefits for water and soil are demonstrated or in priority areas; avoid double funding

RDP funds should be made available for land-based management with improved water and soil outcomes only where high impacts are demonstrated. In the CAP, these could be agri-environment-climate actions (which should build on lower tier requirements, including green payments and cross-compliance) and WFD payments. The use of CAP funds for remedial actions for agricultural water pollution, such as improved manure management, must be avoided. For these actions, the polluter-pays principle applies. Dissipating constrained agri-environment-climate allocations for business as usual management should be avoided.

Ensure that the 2017 and 2019 enhanced CAP reporting demonstrates the outcomes of Pillar 1 greening measures and RDP support for water and soils

The environmental elements of the revised CAP, most notably Pillar 1 greening measures, will be finalised in the Parliament, Council and Commission negotiations in the coming weeks. In the future, their environmental impacts should be rigorously monitored. It should be ensured that enhanced reporting in 2017 and 2019 on the use of CAP expenditure, foreseen in the proposed financing and monitoring regulation[3], adequately assesses impacts of greening measures and other environmental components of the 2013 reform. Such assessments would provide the necessary information to potentially improve sustainability impacts through CAP funds after 2020.

[3] Article 110 of the proposed financing and monitoring Regulation COM(2011) 628/3 under negotiation between the European Parliament and the Council.

1 INTRODUCTION AND OBJECTIVES OF THE STUDY

Water resources are essential for all sectors of the European economy, particularly for agriculture, but are under pressure with regard to water availability, water quality and regular water flows in river basins. The legislative framework for reducing pollution from urban, industrial and agricultural sources has enabled improvements in water quality such as reducing an excess of nutrients. Pressures relating to water quantity affect many parts of the EU, with potential negative impacts when water is over abundant (leading to flooding) or is too scarce (including droughts), and with potential rebound impacts on water quality. Global annual availability of water in the EU is largely sufficient to meet the overall demand: the total EU water abstraction, about 288 km3 per year, accounts for only 15 per cent of the renewable water resources available annually. The problem occurs when in some locations and/or during some seasons or years the demand for water exceeds water availability. Currently, almost twenty per cent of European water basins are experiencing severe water stress (EEA, 2012b)[4]. Climate change may in the future aggravate the situation due to changing precipitation patterns and rising temperatures which can increase the rate of evaporation. To improve the implementation of water policies, the Commission has published a 'Blueprint to Safeguard European Water Resources' in November 2012[5].

Agriculture plays a critical role in the management of natural resources, namely water, soil, and air. It also profoundly affects biodiversity and the associated provision of ecosystem services across Europe, as well as being an important economic activity. Given that over 40 per cent of Europe's total area is under agricultural use, the Common Agricultural Policy (CAP) provides a major opportunity in terms of the scope of measures and budget to influence the management of associated natural resources, water in particular. Therefore, agricultural pressures on water and CAP policies that aim to mitigate these pressures are part of the focus of this study. Sustainable management of natural resources has been identified as one of the three overarching objectives of European agriculture in the legislative proposals for the CAP after 2014, alongside food production and territorial balance[6]. This study only indicates some post-2014 policy changes, inasmuch as these are important for developing the future policy options in relation to sustainable water management. However, a detailed analysis of the post-2014 CAP is not the focus of the present study.

1.1 Objectives, themes and scope

The study aims to provide an overview of issues in the management of water as a natural resource in the EU and the management of natural resources linked to EU agriculture and to identify policy options. It has three focus areas:

- Sustainable water use and water efficiency, while highlighting issues linked to agriculture and rural areas;
- Agricultural land management with soil and water benefits; and

[4] The stress put on water resources resulting from abstraction can be measured through the Water Exploitation Index (WEI) which identifies the ratio of water extraction to availability (EEA, 2010; see Annex 1). A new indicator, WEI+ is refining and improving the current WEI (EEA, 2012b).

[5] Communication from the Commission on A Blueprint to Safeguard Europe's Water Resources. COM(2012) 673. Options identified in the Water Blueprint have not been a focus of assessments in this study. However, potential linkages have been identified in sections on recommended options.

[6] Proposal for a Regulation of the European Parliament and of the Council establishing rules for direct payments to farmers under support schemes within the frameworkof the Common Agricultural Policy. COM(2011) 625/final3.

- CAP measures with benefits to water and soil

The main objective of the study area focussed on the **sustainable water use and water efficiency** is to assess the potential role of **scientific research, technologies and good practices**. The potential impacts of options for sustainable water use and water efficiency on other environmental media, such as soil and biodiversity are addressed as well. The key themes in this part of the study include:

- Scientific research on sustainable water management;
- Technical tools for improving EU water management;
- Good policy practices on efficient water management in the EU, including water pricing.

This focus area takes particular account of practices to save water and reduce or optimise water use in agriculture, linkages between agricultural management and urban and industrial water management, planning and decision-making support tools and good policy practice that may improve water use, water flows and water availability. Technologies and practices relating to water quality are outside the scope of the first part of the study, since they would merit a self-standing analysis. However, trade-offs are discussed where the technologies and good practices for sustainable water use may be in conflict with water quality. An example of such trade-offs is in the re-use of waste water. The study generally stresses issues of water scarcity rather than floods.

In the second study area focussed on **agricultural land management with soil and water benefits**, the main objective is to identify soil management approaches with sustainable outcomes for soils and climate regulation and soils, while noting their co-benefits to water, as well as identifying other land management options for water benefits. This part of the study also aims to note the co-benefits of these approaches to other environmental objectives and soil productivity. The key themes comprise of:

- Agricultural land management actions with benefits to water saving; and
- Agricultural land management actions for improved functions of soils in the context of climate change.

The objective of the third study area focussed on **CAP measures** is to assess the impact and effectiveness of the 2007-2013 CAP measures in incentivising sustainable water use, water quality, regular water flows and sustainable management of soil resources. The assessments address these key themes:

- The effectiveness of the 2007-2013 CAP policy measures for the delivery of water and soil benefits;
- Overview of other national and voluntary policies and economic instruments for the delivery of water and soil benefits; and
- Principles for the effective use of the CAP funds.

As is commonly known, CAP measures are implemented through the structure of two 'Pillars', Pillar 1 comprising most notably of direct payments to farmers and Pillar 2 which supports seven-year rural development programmes (RDPs) designed by Member States and their regions. Both pillars are addressed in the study. A detailed analysis of the post-2014 CAP is not the focus of the present study. Some of the proposed post-2014 policy changes are indicated, inasmuch as they need to be considered in relation to sustainable water management in agriculture in the future years.

Biodiversity loss is an important challenge in agricultural ecosystems. However, the study addresses only the co-benefits to biodiversity from the proposed water and soil options and trade-offs where they occur. A self-standing examination of biodiversity issues is outside the scope of the study[7].

The geographic scope of the study is the EU-27. Exceptionally, relevant examples from outside the EU are presented. The diversity of conditions across the EU has been taken into account, including different bio-physical, environmental, climatic and farming conditions.

The study relies on semi-quantitative and qualitative information collected through EU wide literature reviews. No collection of new empirical data was foreseen.

1.2 Structure of the report

The contents of the report are structured as follows:

- First the key water challenges in the EU are set out, both in terms of water use across sectors, and in terms of water challenges in EU agriculture (**Section 2**).
- This is followed by an assessment of research activities, technologies, good policy practices and water pricing practices with regard to sustainable water use and improved water efficiency (**Section 3**).
- An assessment of the agricultural land management actions for the provision of sustainable outcomes for soils is then carried out (**Section 4**).
- **Section 5** examines the impact and effectiveness of CAP measures for improved water and soil management, and reviews relevant measures outside the CAP.

[7] The interactions between biodiversity and agriculture are the focus of the forthcoming STOA Study 1 Technological and management options for feeding 10 billion people, and another recently published study (Poláková *et al*, 2012) by the European Commission.

2 SETTING THE SCENE: KEY WATER CHALLENGES IN THE EU

2.1 Policy context

Resource efficiency is a key policy issue for the European Union as well as within the global policy frameworks of the UN[8]. At an EU level, actions in this direction were strengthened by making it one of the seven flagships of the Europe2020 strategy in the 2011 Communication 'Roadmap to a Resource Efficient Europe'[9]. The roadmap describes priority actions for 2020 and long-term targets to 2050, with water being one of the key natural resources targeted. Initially water gained policy significance with the adoption of the Water Framework Directive (WFD) in 2001[10], and with the publication of the Communication on water scarcity and droughts in 2007[11]. The recently published Blueprint to Safeguard European Water Resources aims to 'ensure the sustainability of all activities that impact on water, thereby securing the availability of good-quality water for sustainable and equitable water use'. It proposes EU-level actions to better implement water legislation, integrate water policy objectives into other policies, and fill the gaps in particular as regards water quantity and efficiency. The EU Soil Thematic Strategy has driven important awareness and research actions in relation to soils but there is no overarching EU framework for soil management[12].

In relation to water challenges in agriculture, the CAP has been one of the main drivers of increasing specialisation and concentration of agricultural production with impacts on water quality, water quantity and water flows in river basins and soils. Since the 1990s a range of policy measures were introduced to promote sustainable farming due to increasing societal demands on better environmental performance of the sector. The integration of environmental concerns within all EU policies is a principle introduced by the Amsterdam Treaty in 1997, recently reinforced by the Europe 2020 strategy (European Commission, 2010). Several existing Directives outside of the CAP are essential for achieving improvements in water management in agriculture, the Nitrates Directive in particular[13]. Measures under the Sustainable Use of Pesticide Directive and Water Framework Directive can increasingly diminish the impact of agriculture on water[14]. In the post-2014 CAP, water and soil resources will be addressed in one of the three objectives (viable food production, sustainable management of natural resources, and balanced territorial development). It is therefore important to fully understand the potential for addressing sustainable management of water and soil resources through the CAP policy measures. As the next programming period will likely see significant changes to the 2007-2013 CAP, potential changes to the policy context after 2014 have been taken into account where relevant.

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[8] The International Panel for Sustainable Resource Management, www.uneptie.org/scp/rpanel/

[9] Communication from the Commission on Roadmap to a Resource Efficient Europe, COM(2011)571 final.

[10] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework of the Community action in the field of water policy.

[11] Communication from the Commission on Addressing the challenge of water scarcity and droughts in the European Union, COM(2007)414.

[12] Communication from the Commission on Thematic Strategy for Soil Protection1 COM(2006) 231.The proposed Soil Framework Directive has been blocked in the Council in 2010.

[13] Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, OJ L 375, 31.12.1991.

[14] Council Directive 2009/128/EC of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides

2.2 Water use in the EU

Water resources include surface water and groundwater sources, rainfall, and recycling of wastewater (eg 'grey' water drained from showers, washing machines, which can be recycled for specific uses such as irrigation). In Europe as a whole, 37 per cent of the freshwater abstraction ('blue' water) is used for cooling in energy production, followed by agriculture, 33 per cent; public water supply, 20 per cent; and industry, 10 per cent (note that in some cases considerable quantities of abstracted water are returned to water bodies) (EEA, 2012c). In addition, agriculture uses water from rainfall ('green' water), thus using a much greater amount of water in total. The division of water use by sectors, as presented above, masks two major aspects of water consumption. First, the average shares vary among countries. For example, up to 80 per cent of abstracted water in Mediterranean countries is used in the agricultural sector for irrigation (EEA, 2012), whereas irrigation only accounts for 10 per cent in Northern European countries. Second, these shares do not distinguish consumptive water withdrawals from non-consumptive ones (where water is returned to rivers in a partially cleaned or polluted form), as is largely the case for the energy sector. The latter is a crucial factor with regard to water availability. Furthermore, the figures do not take into account the potential impact of 'virtual water'[15], embodied in traded goods.

Whether or not water shortages are an issue depends on geographic location, season and demand for water. However, reducing the pressure on water as a resource can be considered of importance in the whole of the EU, due to the up and downstream consequences as well as the associated impacts (for example reduced energy use for pumping, cleaning and heating water, lower pollution of waterways through polluted effluents). In spite of improvements, a recent report from EEA indicates that almost half of Europe's surface water is likely to be in poor ecological status by 2015 (EEA, 2012a). It also reports that the most common pressures affecting surface water bodies in Europe are pollution from diffuse sources causing nutrient enrichment, and hydro morphological pressures causing alteration in habitats. It is important to bear in mind that in order to solve these problems, policy measures at an EU level (such as safeguards, frameworks and guidance) and measures at a local level (targeted to actual water issues and local conditions) must interact with each other. This could ensure that the actions taken are appropriate both in relation to cross-border issues and to local hydrological, climatic, and soil issues characteristics.

Due to climate change, it is anticipated that the mean annual precipitation will decrease in southern Europe, and increase in the northern countries. Summer precipitation is expected to decrease across Europe, with a potential reduction of up to 70 per cent in some parts of southern and central Europe. Drought events that currently occur on average every 100 years are likely to begin to occur every 50 years in Mediterranean and south-east European countries (Alcamo *et al*, 2007). These changes will impact the whole economy, and especially the agricultural sector because of its heavy dependence on water availability and quality. Identifying and implementing solutions for preventing and mitigating these risks in order to ensure access to good quality water in sufficient quantity for all Europeans is a crucial challenge for the EU.

2.3 Water challenges in EU agriculture

Many aspects of agricultural production affect water. Water is used for irrigation (to ensure crop yields), animal rearing (drinking and hygiene); and on-farm processing. A large proportion of the water consumed in agriculture still comes from rainfall. Agricultural land management across varied

[15] Water consumption can be an indirect effect of consuming other goods or services. The term 'Virtual water' is often used to describe this indirect water consumption in the context of trade.

farming systems also affects water quality, while the magnitude of these effects changes between intensive and extensive systems. Due to specialisation and concentration of Europe's agricultural production over the second half of the 20th century, agricultural drivers continue to have adverse effects on water, soil, climate and biodiversity resources. Although a range of policy measures were introduced into the CAP since 1990s to promote sustainable farming, they have been unable to fully mitigate negative effects on water and soil resources. Important challenges still need to be addressed for the resource base to be maintained for the future food production, as well as for the provision of environmental public goods (Dworak *et al*, 2009; Stoate *et al*, 2009; ENRD, 2010b). Table 1 provides an overview of these challenges and associated trends while Annex 1 presents more detailed data in a wider ecosystem perspective.

Agriculture is the principal source of diffuse source pollution causing eutrophication (EEA, 2012a), responsible for 50 to 80 per cent of the total nitrogen load in Europe's freshwater (Bouraoui *et al*, 2011; Sutton *et al*, 2011 quoted in EEA, 2012a). Diffuse pollution by nutrients and pesticides is the most important challenge highlighted in more than three quarters of Rural Development Plans (RDPs) in the 2007-2013 programming period. Several RDPs identify diffuse pollution or eutrophication in coastal zones, including Finland, Latvia and regions of Spain as the key challenge to address. The mainland Mediterranean countries are concerned in their RDPs about the salinisation of water, an issue which is dependent on treatment technology with implications for greenhouse gas emissions (ENRD, 2010b). Several new Member States, such as Latvia, Romania, Bulgaria, Slovakia and the Czech Republic, identify point pollution of surface waters resulting from lack of adequate water treatment in villages and farms as another issue (Dworak *et al*, 2009; ENRD, 2010a).

Agricultural management has been identified as a key driver causing significant impact on water quantity across river basins in the EU-27. The main problem associated with agricultural management and water use is over abstraction of groundwater. Notably in southern Member States, as much as 70 per cent of water consumed is by the agricultural sector (European Commission, 2012b; Farmer *et al*, 2012). The challenges to water associated with agricultural use are becoming an increasing problem due to the growing number of intensive agricultural systems in Central and Eastern Europe where a large share of farms have converted to intensive systems in recent years (European Commission, 2012b). Illegal abstraction is also of concern, with reports of approximately half a million illegal wells in Spain alone (WWF, 2006 quoted in European Commission, 2012b). The 2007-2013 RDPs indicate that water deficits occur as a result of a combination of factors. For example, RDPs in eight Member States, including the Mediterranean countries, indicate that over-exploitation and increased competition for available water stock between sectors are key threats to water availability. According to the RDPs for Poland and Greece, intensive production methods have a high demand for water and therefore are a significant potential pressure on water supplies. In the Maltese RDP, illegal abstraction of water and salinisation is seen as a long-term issue (ENRD, 2010b). Irrigation systems have been introduced in the majority of the drier regions, in the EU-15 in particular, to ensure stable yields, even quality for example in fruit size and to manage risks in agriculture (BIO Intelligence, 2012). In addition to over abstraction, inefficient infrastructure for water leading to leakages is a cross sectoral issue affecting water availability with an average 50 per cent of water abstracted for public supply lost through leakages (EEA, 2012e). The lack of state-of-the-art irrigation equipment is a particular challenge in the drier areas of the new Member States.

A group of Member States identify changed or irregular water flows in river basins as an issue. These RDPs report that hydrological improvements in water courses in the past were the predominant cause. The recently published report on The Economics of Ecosystems and Biodiversity (TEEB) for Water and Wetlands suggests also that use of drainage, loss of floodplains and wetlands, and land management practices are important factors affecting irregular water flows (Russi *et al*, 2012).

A number of RDPs highlight the need to address the changed or irregular water flows in river basins by maintenance or restoration of wetlands[16]. Other RDPs highlight the need to improve resilience to flooding.

The challenges to water go frequently together with the challenges to soil resources. About half of the RDPs recognise the need to reduce soil erosion and improve soil functionality. Erosion (from both wind and water) is currently estimated to affect almost half of European soils (Turbé *et al*, 2010). Inappropriate agricultural cropping practices and overgrazing are the most important causes of soil erosion. The majority of regions which are characterised by high shares of soils sensitive to soil erosion and at the same time high shares of arable farming are located in Poland, Portugal, Denmark, Italy, Germany and Greece (Nowicki *et al*, 2009). Another challenge to soil functionality in large parts of Europe (45 per cent) is the very low levels of organic matter (between 0 and 2 per cent). The level of soil organic matter in agricultural soils influences not only soil structure but also water and nutrient holding capacity and has an important influence on soil fertility and resilience (Gobin *et al*, 2011). A range of management options addressing soil erosion and soil organic matter levels therefore have considerable benefits for water. These synergies are outlined in Section 4. An assessment of RDPs highlights several agricultural factors adversely affecting soil functionality, such as the abandonment of terraces (Greece), urbanisation (Slovakia), intensive farming (Bulgaria, Estonia), the illegal ploughing of grassland (Poland), desertification (Greece), salinisation (Malta, Romania) and the declining use of land (Estonia). Table 1 provides an overview of the water issues identified in RDPs.

[16] The value of maintaining ecosystem services from wetlands has been highlighted by Russi et al, 2012.

Table 1: Challenges to sustainable management of water and soil in 2007-2013 RDPs

Challenge to sustainable water management	Water issue affected	Member States which identify the issue in RDP
Diffuse water pollution	Water quality	• All EU-15 countries • Majority of EU-12 countries including Bulgaria, Cyprus, Czech Republic, Hungary, Latvia, Lithuania, Poland, Romania and Slovenia.
Water use, especially for irrigation	Water availability	• Mediterranean countries including Cyprus, France, Greece, Italy, Malta, Portugal and Spain • Other countries such as UK, Germany, Estonia, Poland and Romania as well as overseas French RDPs.
Low or Irregular water flows in river basins	Water availability Water quality Resilience to flooding	• About one third of EU-15 countries, including Belgium, Denmark, Germany, Italy and the UK, and Hungary, Slovakia within EU-12 highlight the need for flood protection measures, • Half of EU-15 countries and one EU-12 country highlight wetland functions, for example Denmark, Finland, Germany, Italy, Sweden, UK, Austria and Czech Republic
Soil erosion, Desertification, Salinisation	Water quality (indirectly)	• Half of EU-15 countries including Finland, France, Germany, Greece, Italy, Portugal and Spain • Half of EU-12 countries including Hungary, Poland, Romania, Slovakia and Slovenia

Source: adapted from ENRD, 2010b

3 SUSTAINABLE WATER USE AND IMPROVED WATER EFFICIENCY

This section focuses on ways in which the sustainable water use and improved water efficiency in the EU is promoted, through scientific research (Section 3.1), technological tools (Section 3.2) and good policy practices, including water pricing (Section 3.3). It takes account of approaches through research, tools, and policy practices that are relevant to water use and water efficiency in agriculture and wider rural areas in particular. The range of relevant approaches has been identified on the basis of literature reviews. Each type of approach has been illustrated by one technology and its water benefits assessed in more detail. Finally, Section 3.4 provides recommendations on priority options for sustainable water use and improved water efficiency in the EU. Approaches relating to water quality are outside the scope of this part of the study.

3.1 Overview of EU scientific research on sustainable water use and water efficiency

Scientific research provides new knowledge and underpins innovative application of scientific methods, *inter alia* through technological tools, discussed elsewhere in the report. This section provides a synthesis of the information on the relevant outcomes of the on-going EU research on sustainable water use and water efficiency. The information was gathered by reviewing a selection of FP7 and JRC projects[17]. It provides an overview of the knowledge that is expected to emerge from the EU's scientific platform in the next few years, in particular in relation to agriculture.

3.1.1 Priorities of EU research agenda relating to water

Most of the on-going EU research initiatives on water use in the agricultural sector focus on tools to help devise better water management schemes and develop more efficient irrigation techniques. Research also focuses on Integrated Water Resources Management (IWRM), economic instruments relating to water resources, and other projects focussing on urban or industrial water management. Annex 2 provides more detailed assessment).

The priorities of the European research agenda that relate to water management could be distilled from the Horizon 2020 strategy[18] and the portfolio of relevant JRC work, as well as additional sources such as the proceedings of the 3rd European Water Conference and the Water Science Alliance White Paper (WSA, 2012). A number of studies and recent policy documents highlight that sound scientific results should be adapted to the needs of policy and should be better communicated to decision makers via an improved interface between science and policy. Research is needed to improve data collection and information sharing. It is also needed to improve advice to help evidence-based decision-making by all stakeholders, including farmers, river basin authorities, water managers and policy-makers, and to support the efficient allocation of resources. As well, it can develop technologies and models to improve the understanding of water availability and socio-economic aspects including cost-benefit assessments.

[17] The EU Framework Programme (FP) gather all EU level research initiatives (research, education and innovation) and support research in selected priority areas with the objective of making (or keeping) the EU a world leader in those areas.

[18] Communication from the Commission to the European Parliament, Council, the European Economic and Social Committee and the Committee of the Regions: Horizon 2020 - The Framework Programme for Research and Innovation. COM(2011) 808 final.

In relation to sustainable water use, several EU FP7 research projects (such as the projects 'Water balances and water resources management targets', 'EPI-water' and 'Water cap and trade') attempted to build models of physical water balance. These models were based on water accounts and ecological flows at relatively low resolution and aimed to address the EU as a whole. However, the hydro-economic models revealed important knowledge gaps in the quantitative aspects of water management. These gaps are discussed in section 3.4.

The European Innovation Partnerships on Water[19] (EIP Water) and Agriculture[20] (EIP Agriculture) will identify potential for innovation and create opportunities by bringing research and practice together. The EIP Water will aim to promote sustainable and efficient use of water through the following outputs: innovation and demonstration sites (in urban, rural, and industrial water management), dissemination strategies and the removal of barriers to innovation. EIP Water is expected to boost innovation and the development of solutions for the many water quality and quantity challenges in line with the objectives of the Europe 2020 strategy. However, to achieve the effective implementation of such innovative projects, it is essential to involve local stakeholders. In particular for water, relevant innovation, technology and best practice development must take into account and be adapted to the specific and bio-physical, climatic, agronomic and environmental conditions. The EIP Agriculture aims to establish network of policy-makers, farmers, scientists, farm advisors, enterprises etc to improve communication between science and practice. Within this network, newly established operational groups will test and apply innovative practices, technologies, processes and products and seek to improve innovative outcomes of existing policy measures (such as rural development measures) at local and regional levels. As water is a key resource for agriculture in many regions, cooperation between both EIPs will be beneficial.

The key priorities identified by the Water Science Alliance provide a good indication of pan-European research needs (WSA, 2012). Six research fields were identified as having high priority and are presented in Annex 2. Of those priorities, the most relevant for water management in agriculture are:

- **Water availability for Food, Blue and Green Water, Virtual Water**. Much food produced today is coming from farming systems which compromise sustainable resource base, for example due to poor management of water use. For details on inefficient use of water for irrigation, in certain areas linked to over-abstraction of water resource, see section 3.3 and Annex 4. Improved institutional capacity may be needed to enforce legislative framework related to water and promote sustainable trade in virtual water.

- **Soil functionality as a key factor in the water balance.** The key question underlying this priority is whether soil functionality is sufficient in light of changing land use and climate. This priority recognises that soil types and functions play a key role in protecting underground and surface waters, including mitigating surface runoff and erosion (see Section 4). One major topic to be addressed is how land and soil management, innovative agro-technology and agro-ecology can help protect water resources.

[19] For further information about the EIP Water please see: http://ec.europa.eu/environment/water/innovationpartnership/index_en.htm

[20] For further information about the EIP Agriculture please see: http://ec.europa.eu/agriculture/eip/index_en.htm

- **Water quality – managing unintended effects menacing human uses and ecosystems**. The effect of pollution entering the aquatic environment on ecosystems and species are not discussed in depth in this report, but the recent EEA report and other scientific results show that the effects of diffuse nutrient pollution, including agricultural pollution, have not been sufficiently mitigated by current measures (EEA, 2012a). This research priority therefore focusses on the incentives and instruments for improving water quality.

Another important research area is the **re-use of water for agriculture,** which was identified as part of the Fitness Check of EU Freshwater Policy (Kampa and von der Weppen, 2012). While this measure may increase water availability, more research on policies to reduce barriers to water re-use are needed.

3.1.2 Need for research support

Water is an essential element of two of the priority challenges identified in the Horizon 2020 Framework programme for Research and Innovation[21] ie 'Food security, sustainable agriculture, marine and maritime research and the bio-economy' and 'Climate action, resource efficiency and raw materials', while it will necessarily be an element of other challenges, including 'Secure, clean and efficient energy' and 'Smart, green and integrated transport'. As mentioned above, ensuring continued support to research on water issues at EU level is important since gaps exist in a number of areas. In addition, the newly launched EIP Water and the EIP Agriculture are expected to play a role in supporting innovative actions in both areas.

3.2 Innovative technologies and options for improving EU water management

This section reviews existing innovative and promising techniques and management options that may improve water management, with a focus on application in agriculture. 'Technologies' are here defined as practical applications or tools that are ready-to-use or have already a demonstration status. Upgrading of technology on the basis of state-of-art science has a further potential to provide concrete and measurable results in terms of water savings in the EU (European Commission, 2007a; BIO Intelligence, 2012). 'Management options' are here understood as types of land management that can increase water retention in specific farming systems, and could potentially replace the prevailing land management. This section indicates relevant agricultural management options that should accompany innovative technologies. Detailed assessment of soil management options with water benefits is provided in chapter 4.

There are many ways in which agriculture could improve its water management, including through technologies that make water use more efficient, those that reduce water losses, those that monitor water use for better management and those that target increased water supply, etc. However, two important aspects must always be taken into account when options are considered to implement new technologies, beyond the already important aspects of relevance to the soil types, crops, and weather conditions under which the technology is implemented (BIO Intelligence, 2012).

The first aspect relate to the need to consider the **relevant boundaries of the system to evaluate the sustainability of practices at the pertinent scale of space and time**. If savings are considered only at the field/farm level, it does not mean that the water saved is indeed left in/returned to the water body it stems from and is not used in other fields/farms, or by other stakeholders.

[21] Ibid.

In certain cases it was shown that the water savings, rather than leading to a more sustainable use of water in the river basin, led to an increase in the irrigated surface area. For example, the introduction of hydraulic infrastructures in Spain, while having a positive impact on increasing productivity and rural incomes for farmers, tripled the areas under irrigation (Candela *et al*, 2008). The introduction of drip irrigation also increased areas under irrigation in Spain (Garcia 2002, SAI Platform, 2010).

The second aspect is about the consideration of the **ecosystem benefits** possibly unaccounted for in the baseline assessment. **Water is needed for ecosystems and landscapes that have evolved in certain cases with agricultural practices.** Changing such practices to be more efficient may thus negatively impact their continuation. Water that may be considered lost for productive agriculture is not always lost in a wider ecosystem perspective. Riparian biodiversity may be negatively impacted if technologies used in agriculture increase the amount of soil compaction or soil sealing. Similarly, for example canals and their associated wetland areas may play a role in naturally retaining water, an important ecosystem service that may be lost if these wetland features are removed.

3.2.1 Monitoring of water use

Monitoring tools such as metering and auditing can be used both in agriculture, industry and domestic sectors. These tools aim to measure the amount of water used and to identify any inefficiencies or abnormalities in the distribution systems (excessive water use, leakage, consumption peaks, etc.). Important developments are taking place in the field of monitoring. Already in use are technologies such as remote sensing, as well as GIS and photogrammetry, which provide information about land covers and crops. Box 1 provides examples for the use of remote sensing. Though not specifically targeting water management, these systems enable the assessment of the need for irrigation of land (WaterCore, 2010). A limitation of monitoring tools is that they per se do not save water; it is the subsequent action taken based on the information provided that can save water.

Box 1: Remote sensing

Remote sensing and GIS applications are increasingly used for various applications in agriculture. Although remote sensing does not specifically target water management, the provided information may be used in irrigation-related modelling tools. These tools can help assess the irrigation demand for different crops and schedule irrigation. Also, they can estimate water abstraction for irrigation. In addition, remote sensing can be used for continuous alert systems to identify leaks, fluctuations in pressure and other concerns with irrigation equipment. Annex 4 provides detailed assessment of the technology and case studies.

In **Spain**, a method to quantify groundwater abstraction for irrigation has been developed based on the analysis of multi-temporal and multispectral satellite images (Castaño *et al,* 2010). The results show a very good accuracy of 95 per cent, higher than other indirect methods for evaluating groundwater abstraction for irrigation (ie methods not based on direct measurement). It was also shown that the method is relatively less costly than equipping agricultural fields with meters. In **Greece**, an integrated methodology for estimating water use for agriculture was developed based on remote sensing data. The advantage is that it gathers timely information on a large-scale, which would be otherwise difficult or costly to monitor accurately. However, the methodology would have to be adapted for large basins (Alexandridis *et al*, 2009).

The use of remote sensing and GIS may be very useful at a large scale to estimate, monitor and identify trends spatially and temporally, but is not adequate for individual farmers. Therefore it may play an important supporting role at river basin or national scale. In particular, the European Commission is currently considering the integration of new drought indicators in the indicator system. One of the indicators agreed by the Expert group is the fraction of Absorbed Photosynthetically Active Solar Radiation (fAPAR), which is considered a good indicator to detect and assess drought impacts on vegetation canopies. fAPAR is derived from remote sensing data (European Commission, 2012).

3.2.2 Alternative water sourcing

The use of alternative water sources and managing water sources, for example, through wastewater recycling, rainwater harvesting and irrigation reservoirs, are interesting options to explore in realtion to agriculture, industries and to a lesser extent buildings. Rainwater harvesting technology has been established in Germany as a standard sanitary installation practice for urban areas (Rainwater harvesting, 2005). The collected rainwater is used mainly for toilet-flushing, washing machines and garden watering. In agriculture, rainwater harvesting and the use of reservoirs is a way to regulate the seasonal demand for water through abstraction. Examples of a successful use of reservoirs in agriculture exist, for example from the UK (Weatherhead *et al*, 2010). Wastewater recycling is another promising option to reduce pressure on water bodies, and can be implemented in particular to irrigate green areas, golf courses and certain types of crops. In addition to the benefits for water bodies, wastewater may include nutrients which are useful for plants (Mujeriego, 2007). However, sanitation and safety issues must be taken into account and represent an important barrier to uptake. Box 2 provides an overview of examples and national regulations. Other possibilities of re-use may include recycling of drainage, run-off and irrigation water.

Box 2: Wastewater re-use

Re-using wastewater for several purposes is increasingly used, particularly in the Mediterranean countries. It relieves pressure on water bodies, while also providing a comprehensive answer to water management between urban and agricultural areas (see also Section 0).Wastewater is a quite attractive source of water for agriculture, and for example in Spain approximately 76 per cent of reused wastewater is dedicated to agricultural irrigation (Aquarec, 2006). Other uses are also possible, such as industrial uses, non-potable urban and recreational uses, artificial groundwater recharge and environmental enhancement.

However, wastewater re-use entails risks that are barriers to its spread in the Member States. These risks include microbial and chemical risks to public health, to plant health, environmental risks and issues with public perception/acceptability. However, benefits are potentially large. Wastewater includes some beneficial components for agriculture (nitrates, phosphates), which however need to be closely monitored to limit their excess, control pollution from wastewater, or establish the need to treat it. Table 2 shows the amount of wastewater re-use for irrigation in some Member States.

Table 2: Wastewater re-use for irrigation in the EU

Member States	Wastewater Reuse for irrigation (m3/d)	Intensity of use (m3/d per million inhabitants)
Spain	932,000	23,340
Italy	741,000	12,885
Cyprus	68,000	87,364
Malta	26,000	66,667
Greece	20,000	1,888
France	19,000	324

Source: adapted from (Jimenez and Asano, 2008)

Currently, an important barrier to the use of wastewater is the lack of explicit regulatory framework at EU level which would provide standards about what water can be used and with which level of treatment. Regulations exist at Member State level, which do not necessarily require the same standards. Table 3 gives examples of such national regulations. In addition, different uses may require different standards and not all crops may be irrigated with wastewater treated to a given standard. For example, for horticulture and crops that are not ingested, lower standards may be required that for fruit trees, for which the tree partly filters the water, and then for broad-leaves crops such as salads that include a lot of water that is not really filtered in other parts of the plant.

Table 3: Examples of national regulations on the re-use of wastewater

Country	Regulation	Criteria and/or Standards
Cyprus	Provisional standards (1997)	Quality criteria for irrigation stricter than WHO standards but less than Californian Title 22 (TC<50/100 mL in 80% of the cases of a monthly basis and <100/100 mL always)
France	Art. 24 Decree 94/469 3 June 1994 Circular DGS/SDI.D/91/nº 51	Both refer to treated wastewater reuse for agricultural purposes; follow the WHO standards, with the addition of

		restrictions for irrigation techniques and set back distances between irrigation sites and residential areas and roadways
Italy	Decree of Environmental Ministry 185/2003	Possibility for the Regional Authorities to add some parameters or implement stricter regional norms
Malta	Guidelines applied to irrigation area supplied with treated sewage effluent. Legal Notice LN71/98 forbidding the use of wastewater for the irrigation of any crop for human consumption.	Criteria related to WHO standards distinguishing between crop types
Spain	Law 29/1985, BOE n. 189, 08/08/85 Royal Decree 2473/1985	In 1985 the Government indicated water reuse as a possibility, but no specific regulation followed.

Source: Adapted from Aquarec, 2006

More information about wastewater re-use is available in Annex 5.

3.2.3 Agricultural management options

Agricultural management options include land and soil management approaches and decision support tools. Among soil management approaches, tillage practices have an impact on the structure of the soil and consequently, indirectly, the retention of water for example through water evaporation and run-off. The application of conservation tillage[22] can reduce soil evaporation through a minimisation of soil exposure to wind and sunlight and increases infiltration rates by favouring a better rooting and soil biota. This technique has been associated with 12 to 46 per cent of annual water savings (Hawkins, 2007). Changing crop patterns is also a possible means to save irrigation water, notably by selecting crops or crop varieties which better tolerate water shortages and need less irrigation; or the use of crop varieties which produce more biomass per unit of water (Tardieu and Zivy, 2006). The adoption of these management options provides considerable win-win benefits for climate change mitigation and soil productivity. An in-depth discussion is provided in Section 4.

Decision-making support tools have been identified mainly for the agriculture sector and can involve different types of users. For farmers such tools can provide advice on irrigation scheduling to help determine the optimal use of water depending on the plant's needs. Thus water can be saved through avoiding unnecessary irrigation while the harvest levels are maintained.

[22] Including eg minimum tillage, reduced tillage and mulch tillage, which means the soil and the surface residues, are minimally disturbed compared to conventional tillage.

Box 3 provides detailed information on the benefits of irrigation scheduling. For authorities and advisors dealing with water management issues, decision support tools through computer simulation can help analyse alternative strategies in terms of production and technology, depending on market, policy and climate conditions. IRRINET, an internet based tool, is an irrigation scheduling tool used in the Po river basin in Italy. It provides advice on irrigation timing and volume of intervention by personalised technical indications to the farmers (Giannerini, 1993). This system has allowed an estimated reduction of 20 per cent of the yearly water use in agriculture in the Po river valley for the years 2006 and 2007. The DSIRR[23] prototype programme focuses on water use in agriculture by integrating economic models with agronomic, engineering and environmental information. This programme has been applied in the Po river basin to analyse the impact of pricing policy in a context of irrigation technology innovation. All these support tools can in the future benefit from the information coming out of the research on the Integrated Water Resource Management (for details see Annex 2).

[23] Decision Support for IRRigated agriculture, as described by Bazzani (2005).

Box 3: Irrigation scheduling tools

Irrigation scheduling services advise farmers on when and how much to irrigate. It is the type of irrigation advisory services that is the most widely introduced in developed countries. Farmers generally already use their own experience and indicators (wilting characteristics, soil dryness) to determine the timing and volume of irrigation water (Smith and Muñoz, 2002). However, irrigation scheduling services allow a more precise scheduling, as they take into account weather projections and have more robust and scientific indicators for decision-making. These services to farmers may therefore lead to the savings of irrigation water, although benefits are generally difficult to quantify (Bio Intelligence, 2012).

In the EU, different types of irrigation scheduling services exist, which may target different groups (large-scale commercial farmers, small-holders, farmers groups), be provided by different service providers (irrigation agencies, agricultural research services, private companies, NGOs, etc) and use different means of communication and types of materials (electronic, paper, training, advice, etc).

Examples of irrigation scheduling services in the Member States include:

- Irrigation bulletins are provided in France by agricultural agencies, which disseminate relevant materials and guidelines through newsletters, web-based information, training courses, fax and telephone, based on field data
- Tele-information for irrigation scheduling service is organised by some regional irrigation development agencies in Greece through fax and telephone, based on field data
- IRRINET Plus[24] is an Italian web platform provided by the regional irrigation development agency that informs farmers on the cost-efficiency of irrigating, based on modelling and weather data
- WaterBee[25] is a complete, resilient, cost-effective smart irrigation and water management system. The web sensor networked irrigation system is centrally monitored and coordinated, and the WaterBee services are provided across Europe through collaborating business partners, who work closely with their local customers

Irrigation scheduling is expected to result in improved water management as it increases the efficiency with which water is brought to the fields. For example, it is estimated that in the period 2006-2009, the IRRINET service has allowed a total irrigation water saving of 40 to 50 million m3 per year (Mannini *et al*, 2008; Watercore, 2010; Giannerini and Genovesi, 2011; Draghetti, 2007, see also further information in the case study in Annex 3). However it is often difficult to precisely calculate savings as controls are lacking, and the savings are not necessarily made in the period where they are needed most. Indeed, scheduling is most efficient in wetter periods than in dry periods, as it reduces water put on fields when it is known that it will rain soon, but in dry periods, the scheduling will not reduce the water used.

[24] Further information about the service is available from: http://irrigation.altavia.eu/logincer.aspx

[25] Further information about the project is available from: www.waterbee.eu

3.2.4 Conveyance technologies

Conveyance efficiency is a term used for the efficiency of the networks associated with water distribution for example for agricultural purposes. It is generally a great concern for irrigation districts that supply farmers. For instance, in Greece, average leaks are estimated at 30 per cent for open (non-lined) channels, 15 per cent for lined channels and 5 per cent for pipes (Karamanos, 2005). At the EU level, potential water savings (of the water used for irrigation) through better distribution efficiency have been estimated to be up to 25 per cent. An example of how the water efficiency of distribution systems can be improved is canal lining, however its benefits would come at significant environmental costs. Roughly 60 to 80 per cent of the water that is lost in unlined irrigation canals would be saved by a hard-surface lining. Channel automation is a promising system management technique, with gate systems that properly regulate and measure flows (often based on measurements), to avoid surplus irrigation. However, water lost to ecosystems in lower efficiency systems often supports biodiversity and maintains soil conditions. Potential negative effects through soil sealing and biodiversity decline are discussed in Box 4.

Box 4: Conveyance efficiency

While conveyance efficiency is not a very innovative technology per se, it has been included here to illustrate the trade-offs that may exist between implementing new technologies that aim to improve water management in agriculture with other purposes such as conserving cultural landscapes and promoting biodiversity.

Ways to improve conveyance efficiency include canal lining, replacing open canals with low pressure piping systems, channel automation, measuring water to inform on the efficiency and maintenance. However, there is a considerable amount of evidence on ecosystem services, green infrastructures and natural water retention measures that demonstrates trade-offs between improved conveyance technologies and potential benefits to soil, water and the aquatic and non-aquatic habitats from existing water courses and canals. These multiple objectives and trade-offs have to be seriously engaged with in specific situations. Indeed, technological improvements of landscapes through lining and piping may reduce the permeability of soils and adversely affect the benefits of canals and associated riparian or wet habitats, particularly important for the biodiversity of wider agro-ecosystems and resilience to flooding. All these services should be therefore considered carefully in a holistic manner before new technological improvements in landscapes are made. More information on this technology is available in Annex 6.

3.2.5 Rating tools, certification schemes and labelling

Rating tools are widely used eg in the energy sector to help consumers identify more efficient products. Such tools are also used in buildings across the EU to compare their environmental performance against defined standards and an Eco-label is under discussion for buildings and for certain water-using products such as toilets and taps. Rating alone will not lead to enhanced water performance but the information can be used to identify the areas in which improvements can be made, and help consumers make sustainable choices.

Other types of information can be used to communicate about the environmental performance of products, including methods such as the water footprint[26] and certification schemes that apply to a site, such as the European Water Stewardship. In addition, minimum standards may be introduced to improve the performance of water-using devices in any sector, as done for energy requirements through the Eco-design Directive.

Of course, the use by consumers of rated products will depend upon their views of impacts on the costs of water use (hence a link to pricing) and/or local perceptions of water scarcity. Different types of rating will also provide different type of information, eg footprinting may have to be put in the context of how much water is available, while certification schemes may integrate the local context in their evaluation. Thus, the consequences of introducing a rating system for consumer behaviour are likely to vary across the EU.

3.2.6 Precision irrigation techniques and soil-less cultivation

Surface irrigation is related to a potentially heterogeneous water supply to crops and water losses in terms of water run-off, deep percolation, evaporation and wind-drift. In contrast, drip irrigation systems can significantly reduce water losses because only the immediate root zone of each plant is wetted. In Bulgaria, Koumanov *et al* (2005) showed that on raspberry plantations water savings between 4 and 17 per cent may be obtained through this method without significant reductions in yield.

Soil-less cultivation technique enables plants to grow in water using mineral nutrient solutions in a closed-loop system, with a better control of inputs, tailored to the need of the plant and thus a higher productivity per water unit.

3.2.7 Need for public support

To assess the need for public support for tools and options identified above, it is helpful to review the rationale of public goods. Consensus emerged over the past few years about the concept of public goods being an economically justifiable rationale for the provision of public support to farmers and land managers (Box 5).

Box 5: Environmental public goods as a rationale for support from public budgets

Recent studies have identified a wide range of environmental and other public goods from agriculture, for example landscapes, biodiversity, good water status, well-functioning soils, rural vitality, animal welfare and aspects of food security. Public goods are defined as having two main characteristics. First, they are 'non-rival' which means that if the good is consumed by one person, it does not reduce the benefit available to others. Second, they are 'non-excludable', meaning that if the good is available to one person, others cannot be excluded from enjoying its benefits (Cooper *et al*, 2009; RISE Foundation, 2009).

Compared to the provision of private goods such as food and feed production which are paid for by the market, public goods are often not delivered by markets, or are delivered at insufficient levels, so public intervention is necessary. Where the management actions entailed in the provision of public goods go beyond legislative requirements, incentives through public support

[26] For more information about water labels and footprint, see http://ec.europa.eu/environment/water/quantity/planning.htm#footprinting

may be needed. Such incentives should be designed to encourage farmers to change the management aimed at the production of solely agricultural commodities towards the delivery of public goods or increased levels of public goods (Bromley and Hodge, 1990; Hodge, 2008). However, not all public goods associated with agriculture, for example environmental planning, strategies, mapping, development of tools etc., necessarily require public support for agricultural activity or for farmers.

In situations where environmental public goods may depend on capital investments, eg technological tools or more efficient infrastructure, public support may be sometimes justified. However, the principle of achieving additional (environmental) benefits through such use of CAP or other EU funds should be strictly respected. These must be greater compared to what 'would have happened anyway', ie greater than for example to environmental benefits incidentally arising due to modernisation (see Section 5.6 for detail).

Within the range of the technological tools, monitoring of water use is an essential pre-condition for measuring actual water saving achieved by many other grants for investments into water infrastructure. Other technological tools, such as wastewater use and rainwater harvesting, conveyance technologies and agricultural management, are already eligible for support under the existing CAP Pillar 2 measures (see Section 5). This type of support is expected to be available under the post-2014 rural development policy[27]. Several other technological tools, such as irrigation scheduling and remote sensing, may have certain aspects of public goods. These tools may be used by the public authorities in developing information relevant for land managers (remote sensing) or be integrated in the paid advisory services provided to farmers (irrigation scheduling). Technical assistance to managing authorities and paying agencies in charge of rural development, as well as information, training and advisory measures under rural development policy, may support some elements of these technological tools[28]. Potential support under the EIP Agriculture and EIP Water could be available for knowledge transfer including the development of new technological tools[29].

Several other funds are also available to support investments linked to technological tools. In particular, LIFE+ aims to 'contribute to the implementation of EU environmental policy, the development of innovative policy approaches, technologies, methods and instruments, the knowledge base as regards environment policy and legislation, and the monitoring of environmental pressures'. The proposals for the post-2014 Cohesion and Structural Funds include two directly relevant priorities, 'supporting dedicated investment for adaptation to climate change' and 'addressing the significant needs for investment in the water sector to meet the requirements of the Union's environmental *acquis*', whilst Structural Funds allow for financing the priority 'strengthening research, technological development and innovation'[30]. Under certain conditions, SMEs developing

[27] Proposed EAFRD Regulation COM (2011) 627/3, under negotiation between the European Parliament and the Council: Article 18 (Investment in physical assets) relates *inter alia* to wastewater use, rainwater harvesting, and conveyance technology at farm holdings, Article 21 (Basic services and village renewal in rural areas) relates to similar investments is in built-up areas maintained by the public authorities, and Article 29 (Agri-environment-climate) relates to management actions going beyond the baseline requirement (see Section 6.2) in the proposed EAFRD Regulation COM (2011) 627/3.

[28] Proposed EAFRD regulation 627/3, Articles 15 and 16, relating to knowledge transfer, information and advisory services.

[29] Proposed EAFRD regulation 627/3, Articles 53, 61-63, relating to European Innovation Partnership (EIP) for agricultural productivity and sustainability.

[30] Proposal for a Regulation of the European Parliament and the Council on the Cohesion Fund COM(2011) 612 final/2 Proposal for a Regulation of the European Parliament and the Council on specific provisions concerning the European Regional Development COM(2011) 614 final

innovative tools for water management can be funded through the EU Competitiveness and Innovation Programme (CIP)[31].

3.3 Good policy practices on water management in the EU

This section sets out good policy practices addressing different issues facing water management in the EU. It is important to note that policy practices are distinguished from the application of technical actions, although a policy might be the strategic implementation or support for one or more technical applications to address a specific problem.

The section begins by briefly highlighting the importance of coherent national (or river basin) level policy development for water management. Without a coherent strategic approach to water management, specific policies and technical fixes are likely to be delivered in a fragmented manner. It then continues with sections on policy practices for sustainable water outcomes in agriculture, practices in the urban environment and the interaction between these two. Lastly, it assesses the need for support to these practices.

3.3.1 National/river basin policy context

It is important to note that while specific policies addressing individual aspects of water use are important, strategic policy approaches are also needed as these set out the context within which specific policies can be developed and implemented. In addition, coherence in the way different sectoral policies (eg land-use, agriculture, water, energy policies) are applied is needed to ensure sustainable use of water in the long-term.

A key issue for quantitative water management is the development of drought management planning (article 13.5 of the WFD suggests that such drought management plans could be introduced by MS). A preliminary assessment of the relevance of droughts in current RBMPs by the forthcoming Pressures and Measures study has concluded that, out the 86 RBMPs, 9 have considered droughts to be a River Basin District (RDB)-wide event and 20 considered droughts a sub-basin problem. The forthcoming review of RBMPs submitted by Member States has found that many RBMPs lack any significant analysis of water quantity issues, such as examining future availability and demand. Furthermore, many do not therefore introduce measures to address water scarcity and droughts or to increase the resilience of river basins systems to these extreme events. Thus, the current focus is very varied, and WFD provisions are not necessarily completely coherent with DMPs and vice versa. Thus while there is some good policy practice in this regard, further assessment and planning regarding droughts and wider water scarcity is needed. Good policy practice requires that drought management planning should contain quantitative and measurable targets of water conservation, and a set of measures to achieve these targets which are prioritised according to their performance and implementation costs.

A further policy action that may be appropriate at a national level is the setting of water efficiency targets. The EU Roadmap to a Resource Efficient Europe has established that by 2020 water abstraction should stay below 20 per cent of available renewable water resources. However, a recent EEA report on resource efficiency in Europe (EEA, 2011b) noted that only two Member States (Portugal and Hungary) have set out targets for water efficiency at national level. Although setting national targets could help to drive the development and adoption of specific measures to help deliver those targets, some reports consider them to be inefficient policy drivers. The WaterGap study found that the effects of water saving measures recently implemented or about to be so in Member States are

[31] For further information on the CIP, please see: http://ec.europa.eu/cip/

not sufficient to address the challenges of water scarcity (ACTeon, 2012). Furthermore, the ClimWatAdapt project analysed several climate and socio-economic scenarios to 2050 (Flörke *et al*, 2011) and found that even with strong improvements in water efficiency in all sectors, water stress would remain a problem in numerous EU catchments, including in central and Western Europe. Thus, policy initiatives on water efficiency are needed.

Effective drought and scarcity planning combined with water efficiency strategies are, therefore, important overarching policy pre-requisites to more detailed policy programmes in specific areas such as agricultural water management and urban water management or in determining the objectives and impacts of pricing policies.

In addition to this strategic level planning, long-term planning is also a key need when dealing with water issues. Ensuring that policies and related actions are resilient to climate change and/or guarantee the maintenance or improvement of biodiversity and ecosystem services is necessary for such long-term planning. Studies to climate-proof and/or biodiversity-proof actions are emerging at international and EU level (GIZ, 2011, Hjerp *et al*, 2012, IEEP *et al* 2012) and their methodologies should be scrutinised so that tools can then be systematically used to help decision-making whilst taking into account long-term considerations. The participation of the public in decision-making may also help identify unintended negative effects from some practices.

3.3.2 Policy practices for sustainable water outcomes in agriculture

Good agricultural practice can not only deliver positive outcomes for water quality, it can also be used creatively to address issues such as flood management. Many of the key policy measures are provided in the context of rural development policy under CAP Pillar 2. An example is the use of agri-environment payments for the adoption of management options for improved water retention. These measures are addressed in Section 4. There are also other good policy practices beyond core rural development policy and these are discussed below.

Payment for Ecosystem Services (PES) schemes, publicly or privately funded, are being increasingly explored and used in practical policy making for water management (see Section 5.4). PES schemes allow for the translation of the ecosystem services that ecosystems provide into financial incentives for water protection (Russi *et al*, 2012). Private PES schemes bring economic benefits to both water users (who are subject to a lower cost than those associated with the degradation of the natural resources) and providers (who receive compensation for their protection activities), besides benefitting the ecosystems and the associated natural resources (ten Brink *et al*, 2011). The amount of payment in a PES programme can be established through the monetary valuation of the remunerated service, negotiation among the involved stakeholders or reverse auctions.

Grants and loans for capital investments in water efficiency may also be a useful policy practice. Farmers can be hampered by upfront costs of the capital investments even where this would deliver financial (as well as environmental) benefits. However, this type of support should only be provided if it is demonstrated that the environmental benefits constitute public goods and are additional to 'what would have happened anyway' (see Box 5 and Section 5.5). Infrastructural investment support should be always accompanied by advice and information. In the past financial support to certain farming practices could have resulted in negative impacts on water quantity/quality, for example by increasing areas under irrigation in water scarce areas. Therefore it is critical to ensure proper targeting of funding and eligibility criteria/conditions to grant funding in order to guarantee sustainable results.

A particular challenge arises with historical water rights and equitable sharing of water resources. A policy instrument used to address competing water rights is trading. Spain is the only EU Member State where it is used (since 1999), while other non-EU countries (such as Australia and the USA) have long experience of this type of policy. Trading exchanges are limited in Spain, but it has been concluded that during the 2005-2008 drought period trading helped to alleviate water scarcity. It is important to highlight that the establishment of a cap on total rights (such as using the concept of an environmental flow) should be a pre-condition. Otherwise trading in water rights will not necessarily deliver any environmental benefit. Box 6 presents a few relevant examples.

Box 6: Examples of good policy practices for agriculture and water management

Subsidies and loans for irrigation efficiency

The **Cyprus** government has encouraged farmers to use high-efficiency irrigation methods by offering subsidies and long-term low interest loans for the purchase and installation of improved irrigation systems. This was supported by awareness raising work to demonstrate the benefits of the investment. It is reported that the policy resulted in a major change in irrigation behaviour and irrigation efficiency (Laaser *et al*, 2009), however an evaluation may be needed to understand the net effect on water use in long term. It may be that access to more efficient irrigation allows to irrigate larger area with the same amount of water as before, rather than reducing the water use so that water remains in its natural environment and supports ecosystems.

Payment for ecosystem services

An example is a PES combining private and public funding, the **Sustainable Catchment Management Programme** launched by United Utilities (UU) Group which provides water and wastewater services to approximately 7 million people in the north west of England. UU also owns 57,000 ha of land, much of which is protected. The programme was launched with the objective of improving the water quality. Between 2005 and 2010, the programme covered an area of 20,000 ha and invested £10.6 million in a set of environmental measures to restore drained, burnt and overgrazed moorland and degraded blanket bog, as well as increasing diversity of hay meadow/rush pastures and woodlands. In order to facilitate the engagement of the farmers who leased land within the project area, UU encouraged them to enter in the Higher Level Stewardship agri-environment scheme and, since the agri-environment payment only covers half of the capital investment costs, provided part or all of the upfront costs. UU also implemented another privately funded project in its remaining land (30,000ha), which includes 53 projects and an investment of £11.6 million between 2010 and 2015. The measures included in this second project are similar to the ones of SCaMP and are mainly focussed on water quality improvement (Anderson and Ross, 2011; McGrath and Smith, 2006).

Irrigation advisory service

In Castilla-La Mancha (**Spain**) an Irrigation Advisory Service for Farmers (SIAR) was established. Critical to this is advice on irrigation scheduling, calculating a daily water balance using data from a network of automatic weather stations (EEA, 2009).

Tradeable water rights

A flexible exchange system regarding water usage rights is in place, so that water intended for irrigation can be used to supply water for domestic consumption when needed. Furthermore, the **Spanish** AGUA programme (2004-2008) includes measures such as the establishment of Public Water Banks (Bancos Públicos de Agua), in which water rights can be exchanged (Laaser *et al*, 2009).

3.3.3 Policy practices in urban water management

Water management for urban environments, including such environments in villages and settlements in rural areas and built-in environments on farms, faces a number of challenges. Historically, main policy measures focussed on the supply of clean drinking water and collection and treatment of waste water. In the EU-15, policies in these areas are, therefore, well established, although there may remain potentially significant investment need in some Member States in the EU-12. The principal challenges on the pan-European scale concern the efficiency of water supply, and efficient use of water in buildings and in urban environments. Improvements with regard to these new priorities may contribute to regulating flows and thus may improve resilience to flooding and water quality.

Efficiency of water supply is a major challenge (ERM, 2012). As much as 50 per cent of water abstracted by water service providers for public supply in Europe is lost through leakage from water distribution networks, with an average of 20-30 per cent. The variation between Member States and service providers depends on 'the age and maintenance of the system; the total length of mains; the number of connections; the local topography and thus hydraulic/pressure characteristics; the soil and climatic conditions; the water price at the point of abstraction and consumption and also the manner in which water is valued by society' (EUREAU, 2011). The EEA (2012) stated that 'eliminating leakage entirely is an unrealistic goal because of the costs involved', but 'optimising leakage reduction is a crucial part of water demand management'. The costs of pipe replacement vary significantly between Member States and depend on the repair methods. For example, in Sweden active leakage control is not considered to be cost effective and only large visible leaks are repaired as pipe are buried at a depth of 1.6-4m to reduce the risk of winter freezing (WssTP, 2011). Addressing leakage requires significant investment and in some cases it is considered sufficient simply to ensure leakage rates do not get worse. The current economic crisis is likely to exacerbate constraints on investment, whether from public funds or the ability to pass on costs to consumers.

An important policy within urban design is the provision of Sustainable Drainage Systems (Backhaus *et al*, 2012). These systems aim to improve management of flow rates and volumes from hard urban surfaces, allowing for the control of peak flows (thus improving resilience to flooding) and the decrease in the pollution risk to surface waters. Furthermore, the approach can have knock-on benefits for amenity and biodiversity. An effective policy consists in more than the adoption of a particular technical action (eg a green roof), rather it is the adoption of a management plan for sustainable drainages which identifies a range of components to address the flow and quality of water across an urban landscape and which together provides best achievable outcomes with maximum effectiveness. Examples of these components include:

- Linear wet areas: alongside roads, such wet features allow for water to be conveyed and its quality to be improved. The retention of pollutants in the wetland allows for them to be decomposed.
- Run-off furrow: a shallow vegetated channel, which collects run-off which can be conveyed to other parts of the water management system.
- Permeable pavement: allow water to soak into the ground or a gravel-filled base and so can attenuate the flow and provide treatment.
- Green roof: effectiveness depends on the thickness of the substrate on the roof, it provides attenuation.
- Bio-retention: depressions filled with engineering soil and vegetation so that water enters through a vegetated surface before being transported downstream, providing attenuation and water quality treatment.

There are many policy initiatives currently in place in the EU and beyond to improve the environmental performance of the building sector, eg the BREEAM scheme in the UK, the DGNB in Germany and the HQE in France (Bio Intelligence, 2012b). Public water supply represents 21 per cent of the total water abstraction in the EU, and buildings account for the major use. Considering that the 44 per cent of the abstracted water is used for cooling purposes for energy production and is returned to the environment with little to no treatment needed, water abstracted for public water supply appears to be even more significant. The building sector includes residential buildings and non-residential buildings, the former comprising 99 per cent of the buildings in the EU. The residential water use represents 72 per cent of the total water use in buildings, and 28 per cent for non-residential buildings.

Box 7: Examples of good policy practice for water management in urban areas

Storm-water management policy. The city of Łodz (Poland) in its integrated storm water management policy has introduced a storm water bio filtration system which prevents the influx of effluents into the river during high flows. This helps to reduce flooding and improve water quality (Shutes *et al*, 2010).

Waste-water reuse. The City of Berlin (Germany) re-uses treated wastewater to recharge aquifers and indirectly for drinking water production (see following section for further information on re-use of waste water).

Schemes targeting buildings. Regulations are also in place in several MS and national Governments have announced public procurements to enhance their own buildings as around 40% of buildings tend to be owned or used by the public sector. In this regard, the fact that a building is publicly or privately owned may influence the number of buildings that are being certified. Through a public procurement, a specified share of the buildings publicly owned will be certified.

Rating schemes for water performance of buildings exist in a number of countries. BREEAM is a major scheme with 200,000 buildings with certified BREEAM assessment ratings and over a million registered for assessment since it was first launched in 1990. National Scheme Operators develop country specific local Schemes that are affiliated to BREEAM. In Europe schemes exist in Germany, the Netherlands, Norway, Spain, Sweden and the UK. Other schemes also exist for building certification such as in Germany the DGNB and in France HQE.

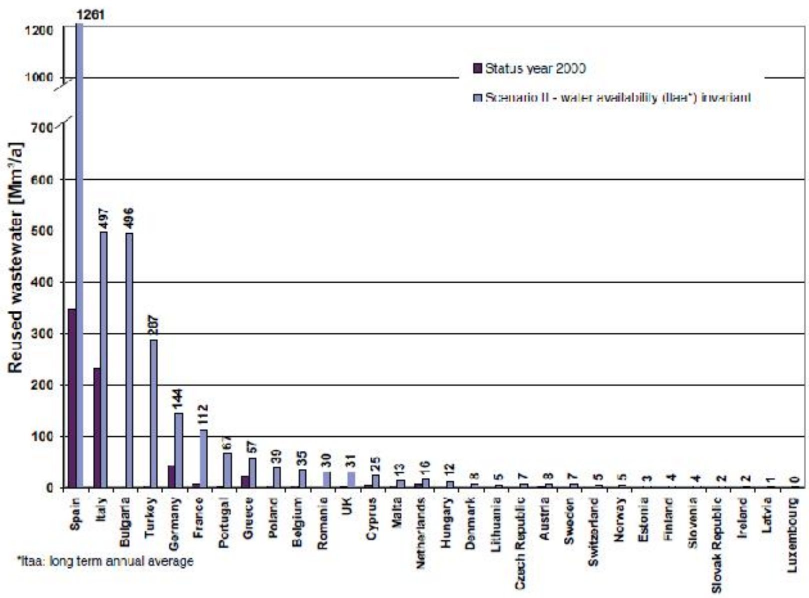
Reducing leakages. In the UK, the economic regulator, Ofwat, and the Environment Agency are developing improved policies for the determination of the Sustainable Economic Level of Leakage to take full account not only of the immediate economic issues for water management, but also of the economics of environmental externalities to ensure these are fully taken into account (Defra, 2011).

Support to environmentally-friendly capital investment. The Enhanced Capital Allowances (ECA) scheme enables UK businesses to claim 100 per cent first year capital allowances (ie tax relief) on investments in technologies and products that encourage sustainable water use. The objective is to encourage businesses to invest in water-efficient technologies and provide key information to accompany them in their decision process.

3.3.4 Practices linking urban water management and agriculture

A critical source of interaction between urban and agricultural water use is the re-use of waste water. Waste water collected in urban systems can, if treated appropriately, be used for agricultural (including horticultural) irrigation (Campling *et al*, 2008). Re-use is promoted by the Urban Waste Water Treatment Directive[32] (article 12): 'Treated wastewater shall be re-used whenever appropriate. Disposal routes shall minimise the adverse effects on the environment.' The total volume of reused treated wastewater in Europe was 964 Mm^3/yr in 2006 (2.4 per cent of the total treated effluent). The reuse rate is highest in Cyprus (100 per cent) and Malta (just under 60 per cent), whereas in Greece, Italy and Spain treated wastewater reuse is between 5 per cent and 12 per cent. However, the amount of treated wastewater reused is mostly very small (less than 1 per cent) when compared with a country's total water abstraction (TYPSA, 2012). A recent EU project modelled the potential for wastewater reuse by the year 2025. The results (see **Figure 2**) show that wastewater reuse has considerable potential in many Member States.

Figure 2: Model output for wastewater reuse potential of European countries; projection horizon 2025.



Source: Wintgens *et al*, 2006

A key barrier to the re-use of waste water is the lack of trust in its safety (Wintgens *et al*, 2006) and, linked to this, a lack of EU standards. This has been strongly emphasised by water industry and agricultural stakeholders in the context of the forthcoming Fitness Check of EU water policy. All stakeholders highlighted concerns that some Member States could create barriers to the importation or sale of crops grown using re-used waste water on the basis of health concerns. This makes farmers reluctant to adopt this approach and the water industry reluctant to invest in treatment. A study found that while the majority of farmers in Cyprus are willing to participate in a water reuse system, almost half of farmers think that consumers will stop or decrease their consumption of food for recycled water-irrigated lands (Birol *et al*, 2007, cited in Bio Intelligence, 2012). These concerns highlight the need for awareness programmes, not only for farmers but also for the wider public.

[32] Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment.

EU level standards would overcome this problem and could ensure appropriate health standards, such as those of the WHO (2006), are respected.

Box 8: Examples of good policy practice for water management in the urban/agriculture interface

In **Cyprus** almost all treated wastewater is reused, primarily for the irrigation of agricultural land, parks, gardens and public greens. A small amount is used for groundwater recharge which may be used as storage for subsequent irrigation. Upgrades to WWTPs allow for much greater supply of irrigation water. For example, the Nicosia WWTP will treat about 55,000 m^3 effluent per day with one third being used for irrigation.

There are over 3,000 ha in **France** where treated wastewater is used to irrigate gardening crops, orchard fruit, cereals, trees, grassland, golf courses.

There are over 4,000 ha irrigated with treated wastewater in **Italy**. One of the largest projects is in Emilia Romagna where 400 ha are irrigated with treated wastewater. 16 reuse projects are being implemented in Sicily and Sardinia (Grammichele, Palermo, Gela).

In **Gran Canaria (Spain)** treated waste water is used for a wide variety of purposes. When developing policies for the reuse of wastewater for irrigation, soil contamination and public health risks/concerns should be taken into account.

Source: adapted from Hochstrat and Kazner, 2009, do Monte, 2007, EEA, 2009

3.3.5 Need for public support

There are a number of good policy practices identified in this section. These should be to a large extent intrinsic part of developing public policies at the national level. Therefore they do not require additional financial support. Rather they require a process of routine checking to ensure that these practices are respected in the use of public funds and consistently implemented. Relating to sustainable water management in agriculture in particular, several types of good practices identified in the study would help deliver environmental public goods. See Box 8 for an explanation of the concept of public goods. Examples of good practices are development of drought management planning at various scales, capital investments into improved water efficiency at farms, eg through the re-use of wastewater for irrigation, capital investments into addressing leakage and introducing elements of sustainable drainage in the built-up areas of farm holdings (see Section 3.3.2). All these good practices are already eligible for support under the 2007-2013 rural development policy, and may be combined with support under advisory (drought management plans) and capital investments on farms (Section 5.4). Similar support measures are foreseen to be continued in the post-2014 CAP33. In the built-up public spaces in villages and settlements in rural areas, relevant capital investments

[33] Article 16 (advisory services and farm management), Article 18 (investments into physical assets) and Article 46 (common provisions for investments including the specific conditions for irrigation) in the proposed EAFRD Regulation COM (2011) 627/3.

may be supported under the rural development measure for basic services and village renewal[34]. Such support can be provided for example to the re-use of wastewater for irrigation of public parks and green areas, for addressing leakage on public water infrastructure and introducing sustainable drainage systems. Business start-up aid for young farmers and non-agricultural activities in rural areas may potentially support certain upfront costs for water related investments[35]. Section 5.5 summarises key principles for assessing the need for the CAP support. The principle of achieving additional water savings is entirely critical for the effective use of CAP funds. Stringent safeguards or eligibility criteria for such additional water savings should be set out for all relevant investments36. Due to concerns with the environmental benefits of irrigation investments in the past, the proposed 2014-2020 rural development regulation sets out strict requirements for support to irrigation infrastructure[37]. These include *inter alia*:

- Identification of the area under a new irrigation investment in a river basin management plan required under the WFD;
- Use of water metering at the level of the supported investment;
- Achievement, in modernisation of existing irrigation equipment, of water savings of at least 10 to 25 per cent;
- Achievement, in irrigation investment that may affect ground- or surface water whose status is already under pressure, of at least 50 per cent of the total potential water saving, and when implemented on farm, reduction of the holding's total water use to at least 50 per cent of the total potential water saving;
- Eligibility of an investment resulting in a net increase of the irrigated area only in situations where the river basin management plan did not identify undue water quantity pressures;
- No significant negative environmental impact demonstrated from the investment through an impartial environmental analysis;
- Further derogations are possible in specific cases

Under the constrained CAP Pillar 2 budget foreseen for 2014-2020 (see Section 5.5), it will be critical to assess the need for the potential CAP support also for other types of capital investments into infrastructure enabling good water management. Any such support needs to be assessed at the backdrop of similar safeguards and eligibility criteria for achieving additional water savings.

[34] Article 21 (basic services and village renewal) and Article 46 (common provisions for investments including the specific conditions for irrigation) ibid.

[35] Article 20 (farm and business development) in the proposed EAFRD Regulation COM (2011) 627/3.

[36] A concern highlighted by the Court of Auditors in relation to the investments into energy efficiency under structural funds 2007-2013 has indirect relevance for water efficiency projects. The Court was concerned that the majority of energy efficiency projects were clearly aimed at the refurbishment of public buildings, although the public support to them was provided for benefits to energy savings. The Court found that the benefits for energy efficiency were a logical outcome of such modernisation projects but were only a secondary consideration in identifying and preparing the projects for support. The Court therefore highlighted that the environmental justification to energy efficiency investments is valid only as long as the environmental benefits from such modernisation are higher than would have occurred in a normal modernisation (European Court of Auditors (2012).

[37] Presidency revised consolidated text of the proposed EAFRD Regulation COM (2011) 627/3, 13 December 2012.

3.4 Water pricing: EU policy instruments and their implementation

Policy mechanisms for water pricing are numerous and can be applied in pursuit of different objectives. The OECD for example, has developed categorisation for three ultimate financial sources of investments for the water sector: Taxes, Tariffs and Transfers (Lago *et al* 2011). The WFD provides criteria for establishing water pricing schemes in Article 9, which introduces the concepts of cost recovery, the polluter-pays-principle and incentive pricing.

The following paragraphs set out the different criteria and instruments for water pricing, including water metering and tariffs. The questions of how water pricing can be used in order to incentivise water use efficiency are also addressed. These aspects are studied with a focus on agriculture, however examples from other sectors (mainly the household sector) are also provided. Finally, the section points out concerns with policy instruments for water pricing, and identifies alternative pricing methods that could help achieve more efficient water resource use. The findings are based on reviews of the literature including reviews of existing case studies. Annex 7 presents in-depth information about the case studies.

3.4.1 Water pricing schemes and instruments

Cost recovery is a policy objective in the WFD that is focussed on the amount of money being paid for water services. The principle covers both the financial costs for the provision of a water service and the costs of associated negative environmental effects as well as forgone opportunities of alternative water uses (environmental and resource costs).

The polluter-pays-principle addresses the adequacy of contributions from the different water uses towards the total cost based on their role in causing these costs. It is generally required by the WFD that payments should be linked to the actual use/abstraction, or that all users should contribute, which could be done through users' water charges for wastewater treatment (Arcadis *et al*, 2012).

Water pricing is more directly related to cost recovery and the polluter-pays-principle than to incentive pricing, which addresses the question how water is being paid for and how price affects the behaviour of water users. Incentive pricing is thus a mechanism to establish the price that aims to reduce the water use and consumption by a certain set of users.

In order to manage water efficiently, particularly in water scarce regions, it is indispensable to have an understanding on supply and demand of water, for example by establishing water accounts. After taking into account ecological flow, the price for water can be set adequately, according to the amount of water available to be allocated for different uses. Setting the price of water right is crucial, as under-priced water may lead to unsustainable use.

Economic instruments for water pricing and cost recovery include tariffs and charges, taxes, as well as tradable permit schemes. They fulfil the WFD requirements to varying degrees and so far focus has been placed on the implementation of one such measure at a time, but newer research has included the use of overlapping pricing schemes (UFZ, 2012). They are generally used as part of the following pricing mechanisms (as defined by OECD, 2012):

- **Regulatory levies** which are used to recover regulatory costs, for example water licensing fees or a pollution control tax, where the fee is set to pay only for the administrative cost of issuing a license to abstract water
- **Pollution and abstraction charges or taxes**, which are based on the user-pays and polluter-pays principles

- **Payments for ecosystem services** for example where users downstream benefit from activities taken by users upstream to reduce consumption or pollution and in return pay upstream users a compensation
- **Permit markets** are markets that aim to facilitate permit allocation and provide incentives for pollution abatement, by allowing polluters who perform better than the required environmental standards to sell excess pollution rights.

3.4.2 Application of water pricing instruments

Prices for cost recovery usually come either in the form of a water withdrawal or water abstraction charge or tax, where a certain amount of money is charged for the direct abstraction of water from ground or surface sources (Roth 2001), or as a charge/tariff for water supply services covering extraction, treatment and transport of the resource (Interwies *et al*, 2006).

Whilst the tariffs for water supply services will allow cost recovery, some pricing schemes also have the potential to cover the needs of the polluter-pays-principle and incentive pricing. For example, the Emilia-Romagna Region in Italy introduced a pricing scheme that reduced water prices for non-irrigators and thus reallocated the costs towards heavier users (see Box 9).

Tariffs will usually include either a volumetric component (where metering is necessary) or a flat rate component. Two-part tariffs combine volumetric tariff with a fixed charge. Flat rate implies a uniform user charge independently of amount used. Volumetric tariffs can: i) be proportional to consumption (linear tariffs), ii) increase with consumption (increasing-block tariffs, IBT), or iii) decrease with consumption (decreasing-block tariffs, DBT). Flat tariffs fulfil cost recovery and are economically viable solutions, but they do not necessarily provide an incentive for more efficient use or meet the polluter-pays-principle (Ecologic 2006). Table 4 shows a detailed, non-exhaustive breakdown of these different types of tariffs.

Table 4: Types of existing irrigation tariffs

Type of tariffs	Description	Advantages	Disadvantages	Case study reviewed
Volumetric	Water charge is based on the direct measurement of volume of water used. Variations of the volumetric approach include: (a) indirect calculation based on measurement of minutes of known flow; and (b) a charge for a given minimal volume to be paid for, even if not used.	Affects water demand and can achieve efficiency in the short run Easy control of demand	Difficult implementation	Cyprus: Water charges cover 34 per cent of the average cost of water provision. Farmers are charged on a volumetric basis or an hourly basis
Output	Irrigation water is charged on per output basis (users pay a certain water fee for each unit of output they produce).	Relatively easy implementation Relatively easy control of demand	Only weakly affects water demand and achieves limited efficiency in the short run	
Input	Water is charged by taxing inputs (users pay	Easy implementation	Only weakly affects water	

Type of tariffs	Description	Advantages	Disadvantages	Case study reviewed
	a water fee for each unit of a certain input used).	Relatively easy control of demand	demand and achieves limited efficiency in the short run	
Per unit area	Water is charged per irrigated area, depending on the kind and extent of crop irrigated, irrigation method, the season of the year, etc. In many countries, the water rates are higher when there are storage works than for diversions directly from streams. The rates for pumped water are usually higher than those for water delivered by gravity. In some cases, farmers are also required to pay per ha charges for non-irrigated ha.	Very easy implementation	No efficiency achieved Difficult to control demand	Greece: Per area charges are common. The proceeds usually cover only the administrative costs of the irrigation network. Spain: The water charges are established per agricultural area and not per volume consumed. The user pays the same amount despite the amount of water used → no incentive for saving water.
Tiered pricing	This is a multi-rate volumetric method, in which water rates vary as the amount of water consumed exceeds certain threshold values.	Affects water demand and can achieve efficiency in the short run Relatively easy control of demand	Relatively complicated implementation	
Two-part tariff	Users are charged a constant marginal price per unit of water purchased (volumetric marginal cost pricing) and a fixed annual (or admission) charge for the right to purchase the water. The admission charge is the same for all users.	Affects water demand and can achieve efficiency in the long run Relatively easy control of demand	More complicated implementation than single tariff	France: Irrigation water is commonly priced by a two-part tariff method, which consists of a combination of a volumetric and a flat rate.
Water market	In some developed economies, markets for water or water rights have been formed and determine water prices.	Affects water demand and can achieve efficiency in the short run	There are issues of acceptability in some MS	

Source: adapted from EEA, Sustainable water use in Europe, 1999

The majority of Member States have already implemented different pricing mechanisms for water, either nationally or at river basin level, in accordance with the WFD. Slovenia, United Kingdom, Romania, Portugal, Malta, Luxembourg, Lithuania, Latvia, Ireland, Italy, Germany, France, Estonia, Cyprus, Bulgaria and Belgium have, in some capacity, implemented volumetric pricing schemes, nationally or regionally. There is ample evidence that volumetric pricing, or water usage charged per unit of use, when applied fairly, provides the most direct incentive for efficient water usage.

Box 9: Tariff structure and application of pricing schemes

The introduction of the **tiered volumetric tariffs** and the removal of the irrigation electricity subsidy in 2010 in Bazau Ialomita (Romania) is credited for a significant reduction in area of irrigated land, and reduced agricultural water usage in the targeted region. Following the tariff introduction, cost recovery is stated to be at 100 per cent.

A **trinomial pricing scheme** was implemented in Emilia-**Romagna (Italy) in** 2006, including: 1) a flat tariff to be paid by non-irrigators, 2) a volumetric tariff paid by irrigators and 3) a charge per unit of irrigated area. One of the main effects of this policy decision was a reduction in water prices for non-irrigators. The measure caused a reduction in water costs for non-irrigators, indicating a successful reallocation of costs towards heavier users and fulfilment of the polluter pays principle.

Source: adapted from, Sardonini *et al*, 2011, Arcadis *et al*, 2012

Policies promoting the installation of meters play an essential role for water pricing, as metered charges of a sufficient price can incentivise reduced water usage. Water metering is a prerequisite for volumetric water pricing. Metering is a means for measuring and monitoring water usage, both for the public supply and direct abstractors / irrigators. Certain Member States regulate water metering at national level. The European Commission report recommends enforcing the requirement on the use of metering in relevant catchments through national water policies. However, in certain locations, such as where water is abundant, interest for installing metering is limited (Arcadis *et al*, 2012). Enforcing metering in relevant situations as a basis for implementing water pricing and cost-recovery principles is also proposed by the Water Blueprint (European Commission, 2012).

Obstacles to metering often occur due to costs associated with the installation of metering devices. In certain cases, metering may also not be appropriate. For example, short term fixed costs may reduce revenues for the water companies, and create financial instabilities. Introducing metering therefore depends on the price elasticity of water demand (ie the expected impact of the pricing scheme on water demand) and on balances between efficiency gains and reduced long-run costs versus a certain increase in short-term costs (OECD 2010), which may be surmountable with good financial planning.

The European Federation of National Associations of Water and Wastewater Services (EUREAU) notes that if a shift to volumetric pricing alone does not induce a significant reduction in water usage, then the investment for metering may need to be reassessed—at least for the sake of water demand management. As metering installation is assessed, benefits such as monitoring and maintaining deliverance efficiency, ie leakage reduction, may be as well (EPI Water, 2011). In the case of England and Wales, the Water Services Regulation Authority estimates that the annual cost of household (not commercial) metering is about 65 €, which is only justified if the value of water saved annually is even higher (EUREAU 2006) (see Box 9). The argument for taking on the cost of meter installations therefore relies on the effectiveness of the planned volumetric pricing to be implemented.

In practice, water metering for permitted abstractions is obligatory in more than one third of Member States, including Belgium (Flanders), Bulgaria, Czech Republic (above monthly or yearly threshold), Denmark, Estonia, France, Malta (groundwater), Lithuania, Romania, and Spain. This list may not be exhaustive, as some other EU Member States also apply volumetric charges which incentivise/depends on some type of water metering. In France for example water tariffs include incentives to speed up the shift to metering. Furthermore, water metering is part of cross compliance (under standards of Good Agricultural and Environmental Condition), as discussed in Section 5.2.

Water pricing in the housing sector

Water metering is currently often applied for household use. Several Member States such as Belgium, the Czech Republic, France, Portugal, and Denmark achieved mandatory installation of meters in all buildings in the housing sector (Arcadis *et al*, 2012). Figure 10 shows coverage across the EU. In Ireland for example, the Government decided on a universal water metering plan, when it planned to shift away from free water use in 2011 (see Box 9). This system is, however, complicated in apartment blocks where metering individual apartments is technically complicated and comes at a cost. Therefore the implementation in Germany which calls for the installation for water metering devices in all new buildings is being continuously implemented since 1993 (see Box 10).

Box 10: Water metering for volumetric pricing

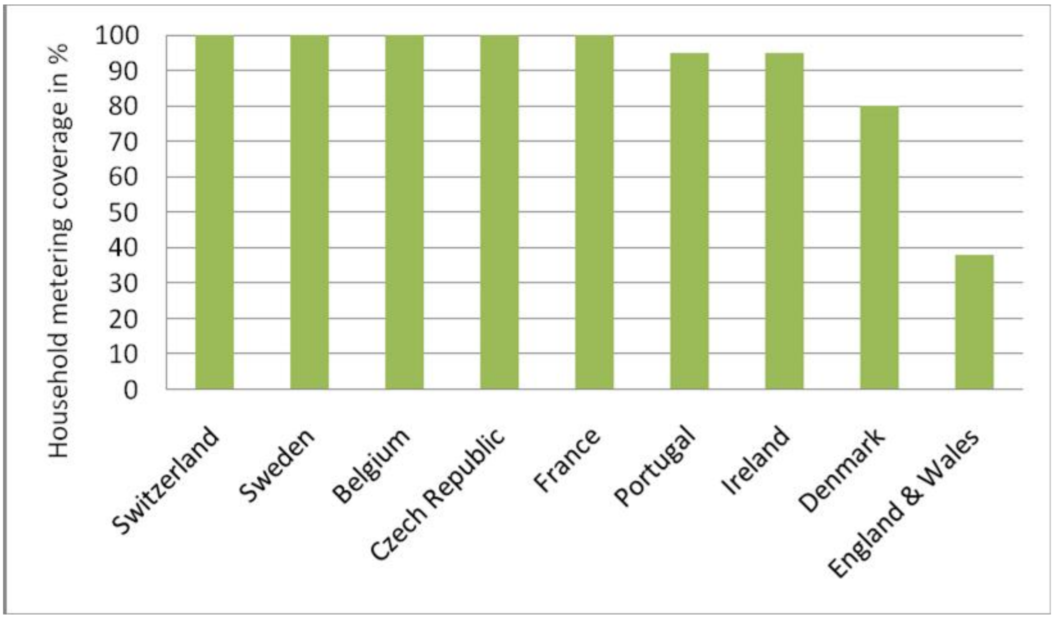
The **UK**'s Water Industry Act 1999 requires the implementation for a metered, volumetric water tariff. The installed water meters in England induce water users to consider the costs and benefits of their usage, as they will have to pay proportionately to their level of use. Although metering is expected to have a net cost of GBP 1 billion (1.27 billion Euro), the cost is seen as necessary for the UK to fulfil WFD obligations. To solve societal concerns, subsidy schemes for lower-income family households are considered.

A universal water meter installation plan was established by the **Irish** Government for 2011-2015. The plan intends to drastically shift the current household (not commercial) water pricing policy in Ireland, where publicly supplied water use was always free, to fully-metered household use. It is expected to create 1500 – 2000 public sector jobs for each year of the programme and to reduce consumption.

In **Germany** a federal ordinance for the installation of water metering devices on all new buildings exists since 1993, to be implemented by the individual Länder (states). There was a rapid decline in household water consumption thereafter for the new buildings.

Source: adapted from Schleich and Hillenbrand, 2007, Viavattene *et al*, 2011, Department of the Environment, Community, and Local Government, 2012

Figure 3: Household metering coverage in Member States



Source: OECD, 2010b

Water pricing in the agricultural sector

In agriculture, users can also be charged according to the area irrigated, the crop cultivated, or a combination (called area-based charge tariff). Users can also be imposed quotas for using or abstracting water (based on area or crop). Quotas at fixed charges do not allow users to exceed their quota, while quotas at marginal volumetric pricing allow exceeding the quota, but at a proportional higher rate. Finally users may be subjected to a seasonal varying tariff where charges (either flat-rate, volumetric or quotas) vary over the course of the year.

However, some countries exempt irrigation from volumetric metering. Although agriculture usage comprises the majority of groundwater consumption, governments are wary of introducing any flat volumetric pricing for irrigation that reflects the true cost of water, due to the impact of increased costs on farmers, and the subsequent impacts on production and food prices (Arcadis *et al*, 2012).

It must be noted that some regions might not have tariff structures in place. This is often the case for groundwater use. For example, in cases where irrigation water is extracted from groundwater sources, farmers often privately fund the infrastructure for water abstraction. Consequently, as private wells are difficult to control and monitor by public authorities, most countries do not use tariff systems to control groundwater use. Instead, other instruments are mostly relied upon to control groundwater use, such as quotas, caps or zoning.

When required from farmers, water metering can be controversial (Arcadis *et al*, 2012). It is clear that farmers' attitudes are due to the water costs they could face, particularly in areas where water was considered as private good and overabstracted, sometimes illegally. Therefore there is an important role for training, communication, and extension.

3.4.3 Incentives for water use efficiency through water pricing

Water pricing has the potential to be a powerful instrument for resource efficiency, promoting economic growth and environmental sustainability. In addition, the revenue raised by water pricing instruments can be used to invest in water resource management to achieve policy objectives. However, water pricing is a complementary policy instrument to enhance sustainable use of water resources. Metering also has an impact if it is linked to incentives for water pricing or quotas and vice versa.

Setting a volumetric pricing policy that brings a fair and effective incentive for water demand reduction is unfortunately not simple. For example, social equity issues have to be considered as well as the quantifiable outcomes. Lower income groups or economic sectors which are strongly dependent on water for production may be negatively affected by a price increase. Another challenge when considering an appropriate price level is the 'price elasticity of demand'. Situations of high-price elasticity favour incentive effects while low-price elasticity favours revenue effects. So far, only a handful of large-scale studies have clearly demonstrated a link between agricultural water prices and a proportional reduction in water use.

Box 11: Incentives for water-use efficiency through water pricing

Between 1980 and 2000, the unit price of water in Hungary rose from almost free to approximately 120 HUF / m3 ($0.50/m^3$). This reduced the quantity of water supplied by approximately 30 per cent over the same time period.

All agricultural water users in France pay a 'water abstraction tax' that is based on the polluter pays principle. The tax is charged on volumetric water abstraction and is directed to national revenue. It is meant to internalise environmental and resources costs. No significant impact of this tax pricing scheme on water usage is observed, due to inconsistencies with rising prices of certain crops, for which the demand elasticity for water is very high. French farmers are more impacted by the energy prices from irrigation.

Source: Adapted from Lallana *et al*, 2001, Smets, 2007, Arcadis *et al*, 2012

An important observation in the incentive pricing experience is the role of energy costs. Examples from Romania and France in Box 9 and Box 11 show that water use has become more efficient when energy subsidies were abolished or when energy prices were high. The removal of an electricity subsidy in the water supply, or an increase in energy prices can have as much, or more of an impact on water-use efficiency, as pricing only the volume of water used (Arcadis *et al*, 2012).

3.4.4 Issues arising in water pricing

A major concern with water pricing is the affordability impacts of water pricing on the users, in particular small farmers and poor households or low-income families. Questions of social equity have been dealt with through water use subsidies (see Box 11 andBox 12). At the same time, considerations about transparency and administrative costs that may work against equity concerns.

Box 12: Social equity considerations

With the goal of full cost recovery, **Denmark** meets water supply costs by metered, volumetric tariffs and environmental and resource costs via taxes. For low income households, affordability is addressed via separate social policies. In 10 years the real price for water increased by 54 per cent and daily per capita water consumption fell from 155 to 125 litres.

Source: adapted from EEA, 2012

Social concerns and problems with public acceptance are relevant to take into consideration when establishing water pricing policies. However, the 2012 Water Eurobarometer points out that eight in ten consumers agree that all water users should be charged for the volume of water they use (including measures to offset negative social effects). Over half of all respondents called for fairer pricing policies and nearly half agreed with the need to have stricter water regulation (European Commission, 2012c).

To enhance public acceptance of water pricing, the introduction of related policies should therefore be the result of a participatory planning process, where the water users understand the need of paying for water resource management functions, share their willingness to pay, and express their demands in terms of use of the revenues.

Other aspects to be considered are both the quantity and the quality of water pricing mechanisms. There is a wide variety of water pricing instruments that can be implemented in theory. In practice, instruments should be carefully selected, based on criteria such as revenue raising potential, administrative complexity, regional and local circumstances and the incentive function. It is also important to consider whether existing instruments can be strengthened before new ones are introduced. The quality of water pricing mechanisms and especially the guidelines concerning implementation are incomplete and lead to an underdevelopment of water pricing. This is mainly due to implementation gaps, differences in the legal systems, lack of guidance and methodological gaps. The European Union Water Initiative Finance Working Group has in their recent publication 'Pricing water resource to finance their sustainable management' called upon the European Commission to establish a CIS Working Group on this topic and to provide more guidance on the implementation of water pricing.

3.4.5 Need for public support

Within the range of policy instruments for water pricing examined above, there are some types of instruments which need to be internalised into the national legislation (eg taxes) or into recommendations on water tariffs (eg correlation between water price and demand; volumetric water pricing). These policy instruments would be introduced as a result of national policy making processes and they do not require additional public support per se. By contrast, capital investments may be required for the introduction of water metering, which is a necessary pre-condition for the monitoring of water use and achieving water savings, in agriculture in water scarce regions in particular. Capital investments for farm modernisation are already eligible for support under the 2007-2013 rural development policy, and may be combined with support for training and advisory

(Section 5.4). Similar support measures are foreseen to be continued in the post-2014 CAP[38].The Cohesion fund can be also used for capital investments to support water pricing, eg the installation of water meters. The principle of additional benefits achieved through support to water meters should be always respected (see Section 5.5).

3.5 Recommended options

As discussed in the previous sections, water has many uses across sectors and is a regional and seasonal issue, also depending on the yearly conditions. Water scarcity is an increasing issue throughout the EU, expected to worsen with climate change, although the scarcity effects vary across the regions. Agriculture is a major water consuming sector, and especially irrigation water use is very high in the Mediterranean regions. Based on the previous analysis, this section sets out several recommended options for a range of stakeholders, from EU level to local levels.

Table 5 presents five priority options and several supporting options.

Table 5: Recommended options for sustainable water use and water efficiency

Priority options	Initiated/implemented by whom	Urgency
Fully implement and enforce water policies at national level	National/regional authorities, river basin authorities, water companies, farmers and other water users	Short to long term
Better integrate water priorities into agricultural and energy policies; climate- and biodiversity-proof river basin management measures	European Parliament and European Commission, national/regional authorities, river basin authorities, water companies	Short term[1]
Reduce water losses, increase water savings and efficiency through technological options including water metering and water re-use, and non-technological options	National/regional authorities, river basin authorities, water companies, farmers and other water users; European Parliament and European Commission[2]	Short term to medium term
Improve decision-making through the provision of better information and improve water allocation rules	European Commission, EEA, national/regional authorities, researchers	Medium to long term
Ensure that the EU funds are used in an efficient and effective way	European Parliament and European Commission, national/regional authorities, managing authorities, paying agencies	Short[1] to medium term
Supporting options		
Continued support for research related to water, innovative research themes and cross-sector cooperation		
Establishing national targets for water efficiency objectives that use common criteria and definitions		

[38] Article 16 (advisory services and farm management), Article 18 (investments into physical assets) and Article 46 (common provisions for investments including the specific conditions for irrigation) in the proposed EAFRD Regulation COM (2011) 627/3.

agreed at EU level
Improved institutional capacity at national and regional levels and provision of guidance, training and advice to farms, water managers, businesses and consumers; networking and experience sharing across river basins
Developing payments for ecosystem services and promoting public-private partnerships
Examining the potential of existing environmental labelling schemes to incorporate water impacts in a coherent manner.

Notes:
1. Urgent action is needed given the advanced programming phase in Member States
2. The European Parliament can request the Commission to introduce a regulation on water re-use

All recommendations are linked to those proposed in the Commission Blueprint to Safeguard Europe's Water Resources. It is important to note that we consider the options recommended in this report to be entirely consistent with the proposed actions of the Blueprint. However, the Blueprint focuses on EU level only. By contrast options recommended here also address potential actions to be taken by national and regional authorities, paying agencies, farmers, foresters and private businesses, and NGOs. The recommended options are further described below.

- **Priority option 1: Fully implement and enforce water policies at national level**

The body of existing water policies at EU level addresses the majority of relevant issues impacting on water use and water efficiency as assessed in the Water fitness check[39]. The Water Framework Directive (WFD) is an overarching policy instrument that should drive improvements across the EU. Better enforcement and implementation of the whole regulatory framework at national and regional levels is essential for reducing negative impacts on water, including impacts from agriculture. Stopping illegal water abstraction is one of the key improvements needed. This requires action at national and regional levels as well as significant behavioural change by water users. A GAEC standard on authorised water use must be maintained and more stringently enforced, for example by better communication between cross-compliance control and water inspectors. Technological tools are available to support this change, for example the use of GMES and remote sensing.

- **Priority option 2: Better integrate water priorities into agricultural and energy policies; climate- and biodiversity-proof river basin management measures**

Water priorities that have been articulated at the EU level need to be more fully integrated into and well implemented through sectoral policies at EU, national and regional levels. Negative incentives from other policies on water use and water management should be reduced. Energy and agriculture are major users of water with a heavy impact on water quality. Policies relating to these sectors must address these water impacts more fully so that their long-term sustainability is ensured. While each sectoral policy has its own legitimate priorities, the sustainable use of resources should be an overarching goal. Therefore, stringent safeguards should be used in agricultural and energy policies. In particular, safeguards introduced into bioenergy policies should ensure that biomass cultivation and extraction does not lead to further pressure on soils and water. On the other hand, water managers should climate- and biodiversity-proof the proposed river basin measures and water infrastructure investments. This should ensure that implementation of water priorities benefits wider ecosystems in the long-term, particularly where major capital investments are involved (eg, in irrigation and flood defence). The proofing approaches can also ensure that multi-functional land

[39] For details, please see: http://ec.europa.eu/environment/water/blueprint/fitness_en.htm

based measures are used where possible, thereby minimising demand on land being taken out of food production. Tools and criteria for proofing can be set at EU or national levels and targeted to specific policy issues and regional conditions.

- **Priority option 3: Reduce water losses, increase water savings and efficiency through technological options, including water metering and water-reuse, and non-technological options**

Several complementary approaches must be promoted to increase the sustainability of water use and meet the EU resource efficiency targets. Firstly**, water savings and more efficient use of water should be achieved through water metering**, i**mproving irrigation efficiency, reducing leakages to a sustainable economic leakage level, and irrigation scheduling.** In particular, water metering allows managers and users to measure how much water is used, but also identify any abnormalities (eg, from leaks) and helps piloting water management programmes, as well as ensuring that authorised water use. Water metering should be therefore introduced and enforced via national and regional water policies, which could potentially target water scarce areas or water-intensive cropping systems to reduce the implementation burden on water users and farmers across the EU. Alternatively, the metering requirement can be subject to preliminary risk assessment (eg using a WEI+ threshold value). Secondly**, improved water availability should be achieved through water re-use, rainwater harvesting and storage**. Water re-use is a very important option in water-stressed areas in particular, facing sanitary and acceptance barriers at present. Therefore, EU-wide legislation should be adopted to define standards. This would allow free movement of agricultural products grown using such water. Thirdly**, improved land and soil management** approaches will provide important water benefits (discussed separately below).

- **Priority option 4: Improve decision-making (by farmers, consumers, RB authorities, policy-makers) through the provision of better information and improve water allocation rules**

Water is, to a large extent, a local issue but with cross-border dimensions and subject to change in time, so the same activity in different catchments, years or seasons may not have the same impact. Improved tools that provide information at the timely manner and at right scales and resolutions are necessary for policy makers, businesses and farms. Decision support tools should be developed and used more widely, for example **irrigation scheduling** that informs farmers when and how much to irrigate. Robust **methodologies for defining/calculating water accounts and ecological flows to inform water allocation and pricing** are critically needed. Water accounts at river basin level have to be refined and standardised at EU level. Water allocation should especially ensure ecological flows are maintained and then use policy or economic instruments to allocate the remaining water resources for other purposes.

The lack of adequate allocation of water for specific users in river basins undermines both water objectives and confidence in the management system. Ecological objectives and economic and social criteria should be developed to determine priorities consistent with ecological flows. These can be used to establish overall, seasonal and intermittent water allocations. Much data that can underpin water allocation is already available but not necessarily reported in a unified and comparable manner. Therefore, the European Commission and EEA should require Member States and river basin authorities to gather and report data necessary to measure both quality and quantity of water and define accurately ecological flows. This is an urgent action, as water allocation and price setting depend on it. In addition, environmental costs and benefits must be taken into account in economic and policy decisions. A thorough **cost-benefit analysis including externalities,** as required in the WFD, is an appropriate tool for this. Therefore it should also inform the CIS guidance document on water allocation and trading schemes. Further actions required to improve information are: update of the guidance document on water and economics, underlining the cost-recovery, polluter-pays principle and user-pays principle components (as defined in the WFD) which was developed in 2003; new guidance document on water allocation, addressing water accounting, water trading and how to balance water demand and use, and raising awareness and public participation relating to water management problems and solutions; eg through change in consumer choices by incorporating water issues in environmental labels etc.

- **Priority option 5: Ensure effective use of EU funds aimed at improvements in water infrastructure**

Certain capital investments to increase water efficiency, metered water use, and water savings may merit public support under Structural and Cohesion funds, Rural Development, EIB loans, and LIFE+ funds. However, EU funds should be granted only for such modernisations that provide additional environmental benefits over and above that which would have been achieved without the funding in place. The grants should thus comply with stringent eligibility criteria and safeguards to prevent negative net effect on water use in water scarce regions. Safeguards **should address eg irrigation efficiency, water use reductions, water re-use and water pricing/cost-recovery.** When funds are granted, it is important to ensure that the project respects overarching EU objectives, including environmental objectives, and that their actual outcomes for water are monitored and evaluated. Funding should be avoided for projects that may impede achievement of these objectives, or that are not an adequate response to environmental needs. For example, it is justifiable to avoid funding a desalination plant where illegal abstraction is high. Tools such as **cost-benefit assessments** and/or proposing funds or loans to cover capital costs that would be reimbursed by the savings made through better efficiency may be introduced. The EIP water can play a role to develop relevant criteria for investments with greatest additional environmental benefits that could be used to prioritise funding and/or loan instruments.

- *Supporting option: Continue supporting scientific research relative to water, innovative research themes and cross-sector cooperation*

Activities focussed on water issues in Horizon 2020 and JRC research programme need to continue, to develop the basis for evidence-based decision-making and offer tools for delivering sustainable water use. Further research is necessary on genetic resources for more water-efficient crops, agricultural practices to reduce water intensity, and to identify perverse incentives to water use. EIP Water and EIP Agriculture should cooperate on relevant topics (eg, agricultural water use use of wastewater in agriculture, irrigation requirements, tackling illegal abstraction).
The Secretariat in charge of each EIP should coordinate such initiatives from the very beginning of the EIP process to facilitate future collaboration and encourage the participants to the EIP to propose relevant topics.

- *Supporting option: Establishing national targets for water efficiency objectives that use common criteria and definitions agreed at EU level.*

Water efficiency improvements are slow due to the lack of strong national policy drivers in most Member States. National targets should be set focussing on the activities that use most water and/or those deemed most water inefficient (eg, for new housing). These targets can be then elaborated into specific requirements addressing those activities. Progress towards targets should be monitored, reported on and assessed.

- *Supporting option: Improved provision of guidance, training and advice to farms, water managers, businesses and consumers; networking and experience sharing across river basins*

Ensure that farm advisory provides information and guidance services relative to water savings and water efficiency to farmers, especially in water-scarce regions since the frequency of type of information is currently low (see Section 5.4). Advisories should also be a relevant channel to provide information to farmers on the benefits of sustainable water use, soil water retention measures, etc.

- *Supporting option: developing payments for ecosystem services and promoting public-private partnerships*

Water ecosystems provide a wide range of services with major economic benefits that users often take for granted or upon which other users have an impact. Payments for ecosystem services schemes deliver a direct economic relationship between the environment and users and deliver ecosystem protection.

- *Supporting option: Examining the potential of existing environmental labelling schemes, certification schemes and rating tools to incorporate water impacts in a more coherent manner.*

Existing environmental labelling and certification schemes should be examined in order to establish the potential to include a water criterion and to identify products with highly sustainable water impacts. However, the number of schemes should be limited to avoid confusing the consumer. An Eco-label in preparation for buildings is a useful EU-wide instrument that provides information on high impacts for consumers. Green Public Procurement can act as a driver for stimulating water efficiency innovation.

4 AGRICULTURAL LAND MANAGEMENT ACTIONS FOR THE PROVISION OF SUSTAINABLE OUTCOMES FOR SOILS

The following passages set out agricultural land management actions with benefits to water saving (Section 4.1) and for improved soil functions (Section 4.2). The relevant types of land management actions have been identified on the basis of a literature review. The emphasis is on sustainable soil management actions addressing soil erosion and maintaining/enhancing soil organic matter (carbon stocks) in particular. Their potential co-benefits and trade-offs with water quality and quantity, biodiversity, other environmental objectives and farm income have been also addressed. Section 4.3 considers the extent to which public support may be needed to incentivise improved soil management. Finally, Section 4.4 sets out recommended options.

4.1 Management actions for improved water availability

There are many agricultural management actions that may be used in practice to improve water use. This study has assessed crop related management actions in particular. These can be classified in three following categories[40]:

- Management actions related to optimising the crop patterns
  - Changes of the crop cycle
  - Choice of species inherently drought tolerant
  - Choice of varieties inherently drought tolerant
- Management actions related to increasing soil water retention
  - Tillage
  - Mulching
  - Application of soil amendments or conditioners
  - Weed control
  - Fallow
  - Intermediate crops
  - Modification of the soil surface
- Management actions reducing crop water needs by optimal management of the leaf canopy

These management actions are possible ways to save irrigation water. Savings can be achieved by reducing the water demand of crops, mostly in cases of water stress in summer. Alternatively, savings can be achieved by improving the water retention of soils, provided that rainfall has been sufficient in winter and spring, so that it is available in soils at the beginning of summer, or provided that rainfall is sufficient in summer. Each of these crop management actions has certain co-benefits for other environmental priorities or the farm's economic objectives and certain trade-offs. For example, tillage may help to control pests and weeds, a benefit lost in case of no-till practices that save water; or conserving crop residues provides benefits for water and soil organic matter but may reduce the economic opportunity of using agricultural waste for bio-energy production. Since there are numerous other factors involved, the optimal strategy must consider prioritisation between these various benefits and objectives and be tailored to local conditions.

[40] Agricultural management actions related to precipitation or irrigation have not been analysed in detail.

Annex 8 provides more details about the management actions set out above and a more in-depth assessment of soil water retention techniques, taking as example tillage and mulching.

In addition to water saving crop management, there is a range of natural water retention approaches which can be applied both on farmland and in wider ecosystems. These approaches can limit the negative effects of floods and droughts. The Blueprint to safeguard Europe's waters mentions several natural water retention measures (NWRM) such as restoring floodplains and wetlands, maintaining or creating buffer strips as well as the provision of green infrastructure (European Commission, 2012a). Other potential NWRMs are re-meandering of rivers, the creation of buffer ponds in headwater catchments and polders aimed at cutting off the peak discharge of floods (Burek *et al*, 2012). The main purpose of these measures is the reduction of surface runoff following rainfall events in order to reduce flood risk. They also offer multiple co-benefits for reducing erosion and leaching, increased groundwater recharge and climate regulation. However, since a recent report by JRC studied the effectiveness of NWRM in detail, they are not being further examined within the present study.

To stimulate the adoption of management actions targeting specific water needs, information and training should be provided to farmers. The advisories can provide such information on a permanent basis or target specific advice provision to the periods of water stress, for example in summer.

4.2 Management actions for improved functions of soils

Sustainable soil management is of particular importance in the context of climate change mitigation and adaption in the agricultural sector. This section therefore provides a short overview of the best actions in soil management which are available to farmers and which can contribute to mitigation and adaptation efforts in the agricultural sector. It aims to develop elements of good policy practices under water management part of the study (themes 2 and 3), present key considerations for targeting soil management to soil conservation objectives in relation to climate change (theme 4 of the study), and lastly to summarise the potential co-benefits of the relevant management actions for water, other environmental objectives and cross-sectoral implications. Annex 9 provides the in-depth information on these management actions and, where information was available, indicates potential obstacles to implementation, technical and environmental limitations and cost considerations.

4.2.1 Relevance of soil management under climate change

Management of agricultural soils is of much importance in efforts by the agricultural sector to contribute to climate stability and meet the challenge of adapting to climate change. The recently published 'Roadmap toward the low-carbon economy' (European Commission, 2011a) emphasises the task that European agriculture has in meeting the ambitious EU mitigation strategy and in particular also the role of land use and soil productivity[41].

[41] According to the Roadmap, the agricultural sector could reduce its non-CO_2 emissions by 42 to 49 per cent in comparison to 1990 levels (European Commission, 2011a). These non-CO_2 emissions include CH_4- and N_2O emissions which arise from land management and which are comprised under the Land use, Land use Change and Forestry (or LULUCF) accounting. LULUCF emissions/removal are not yet incorporated in climate reduction targets although its importance is expected to increase with time. In fact, non-CO_2 agricultural emissions are projected to comprise a greater share of total EU emissions in 2050 compared to today (European Commission, 2011). This further underscores the need for action. The accounting rules for emissions and removals related to land use, land use change and forestry (LULUCF) were formally approved by the European Parliament in March 2013.

While the Roadmap is not a binding document, it gives a good indication of the importance of agricultural sector in the mitigation context. Moreover, the anticipated risks from climate change impacts, such as water scarcity and increasing droughts, temperature extremes, soil erosion or precipitation extremes, also require adaptation responses both at the farm and sectoral level beyond the scale and effort seen so far (Iglesias *et al*, 2007). Annex 1 provides an overview of threats to European soils. However, there is no overarching regulatory framework for soils at the EU level and soil degradation, affected significantly by agriculture, is a concern in many parts of the EU. In absence of agreement on the proposed Soil Framework Directive, the standards for good agricultural and environmental condition (GAEC) within the CAP, and agri-environment schemes, are an essential means of maintaining the soil resource and preventing its further degradation (see Section 5).

Soil management practices can make important contribution to mitigation and adaptation objectives. They are also central to sustainable farming, including the need to maintain soil, biodiversity and water for continued food production. From farmers' perspective, soil management practices often lead to improved nutrient management and reduced need for inputs (fertilisers, machinery) thus resulting in cost savings, improved resource efficiency, and potentially greater economic stability. From a mitigation perspective, soil management practices at farm level play a role by:

1. *Preserving existing carbon content in agricultural soils*
   Soils provide immense carbon storage, containing twice as much carbon as is contained in the atmosphere (Smith, 2012). The existing stores are particularly important in carbon rich organic soils, as well as in semi-natural grasslands. Practices such as the maintenance of grasslands, avoidance of drainage of organic rich soils such as peat soils, or rewetting of organic rich soils lead to important reductions of carbon emissions from land use.

2. *Increasing sequestration of carbon in soils*
   Soil management can increase soil organic matter content in mineral and organic soils, leading to carbon sequestration. Studies have demonstrated that soil carbon sequestration provides a significant additional cost-effective mitigation potential (Smith, 2012).

3. *Reducing nitrous oxide (N_2O) emissions associated with agricultural land use*
   Soil management, especially through the application of synthetic fertilizers and tillage activities, accounts for a significant share of N2O emissions in agriculture (Smith *et al*, 2007). A number of practices are available to farmers to reduce or avoid these emissions.

In terms of the overall mitigation potential, the first priority for management and policy is the protection of the existing carbon content of agricultural soils and avoidance of emissions due to the sheer amount of carbon stored in the soils and the fact that restoring carbon stocks is a long-term process (Smith, 2012). The mitigation potential for sequestering carbon is higher than for reducing N2O emissions (Frelih-Larsen *et al*, 2008); however, carbon sequestration has more limitations (saturation, non-permanence, displacements, verification problems), whereas reductions in N2O emissions are permanent and non-saturating[42].

[42] 'Saturation' refers to the phenomenon where soil carbon stocks reach a maximum level. 'Non-permanence' refers to the possibility for sequestered carbon stocks to be lost once climate-friendly management ceases. 'Displacement' refers to the offsetting of emissions that are saved in one area by intensification of production in another area. To verify (and compensate for) how much carbon is sequestered requires monitoring and verification methods which increase transaction costs.

Beyond mitigation outcomes, soil management practices can also deliver a number of benefits for adapting to changing climate conditions such as the greater frequency and intensity of extreme events. In effect, many mitigation practices are simultaneously very important for delivering improvements for adaptive capacity of agriculture, thus potentially contributing to EU adaptation objectives (European Commission (2009b). Soil management can contribute to adaptation by improving soil quality and structure and thus enabling soils to deliver many vital ecosystem services which in turn contribute to the resistance and resilience of agricultural ecosystems to climate change, for example, by:

- Preserving the productive capacity (fertility) of soils
- Improving the infiltration capacity and reduced run-off,
- Reducing soil erosion and nutrient runoff;
- Improving water holding capacity of soils (eg through addition of soil organic matter which is especially beneficial on sandy and clay soils);
- Reducing vulnerability of crops under drought conditions;
- Reducing pest / pathogen risks to crops; and
- Slowing down water runoff and reducing flood risk.

Soil management practices relevant for mitigation and adaptation also have substantial synergies with environmental protection in general, including, for example, by leading to reduced nitrate pollution of water bodies, reduced pressures on water abstraction, as well as protection of valuable habitats and biodiversity. Annex 9 provides detailed information on co-benefits of individual soil management actions, including co-benefits to farmers.

Management practices can overlap in their effects and have a different potential to contribute to different environmental objectives depending on the regional soil and climate conditions, as well as having varying economic impact. Soil risks, and the related priorities for soil management, also vary considerably from place to place, even between different fields. Three broad approaches have been used to date by Member States to identifying the hot spot zones where improved soil management is a priority. These include: regional/local mapping or zoning; identification of land with certain characteristics (for example topographical criteria such as slope gradient); and farm or field scale soil assessments (Poláková *et al*, forthcoming). There are several good tools for identifying priority soils, such as already degraded soils, soils prone to specific soil threats, and carbon rich soils) at the regional level. For example soil maps and soil inventories are used in several countries. It is important to emphasise that considerably more data tools are available for soil erosion than for soil organic matter and carbon rich soils and this is one of the factors impeding the adoption of appropriate management in hot spot zones (Poláková *et al*, forthcoming). The identification of priority risk areas is of high importance to avoid ineffective use of public funds. In addition, in some instances some soil management practices could reduce the amount of available productive land, or lead to a decline in crop yield and increased need for chemical control. It is therefore important to take these aspects into consideration when selecting the most appropriate practices for specific contexts and designing and targeting policy support.

4.2.2 Overview of relevant soil management actions relating to climate change mitigation and adaptation objectives in agriculture

This section provides an overview of relevant soil management actions that address mitigation and adaptation in agriculture simultaneously. Based on an extensive literature review, a short description of the practice is provided. These descriptions are followed by a summary table of the synergies and trade-off effects that the management actions have for soil protection, water management, and biodiversity conservation objectives (Table 6). The management actions are grouped into three categories: cropland management, grazing land management and cross-cutting actions.

Cropland management

Winter cover and catch crops: Winter cover crops / catch crops are grown between successive plantings of a main crop, typically sown after harvest. In some cases they are under-sown below the crop in spring. These crops are often ploughed into the soil. The main objectives are to minimise exposure of bare soil and mitigate soil erosion, improve soil organic matter and soil fertility and to take up surplus of nitrates to avoid its leaching.

Crop rotation: Involves a succession of crops, often with legumes or grassland in first sequence to regenerate the soil. The measures aims to improve or maintain soil fertility and soil structure reduce erosion and may increase soil organic matter.

Adding legumes or N-fixing crops to rotation or under-sowing: Nitrogen fixing crops, including beans, peas, lucerne and soya, can be added to cereal rotations. The measure can target increase in soil organic matter and reduce the need for fertilisers.

Reduced tillage: Reduced tillage can take many forms including ridge tillage, shallow ploughing and rotation or scarification of the soil surface. Reduced tillage maintains organic matter, preserve good soil structure and reduce erosion. Minimum tillage may be the best way to maintain organic matter and soil structure.

Zero tillage: By excluding tillage, negative effects such as loss of organic matter, soil compaction and soil erosion can be reduced and water protection be improved.

Crop residue management: Involves incorporation of stubble, straw or other crop residue in soils when the field is tilled. Moreover, soil organic matter can be composted and returned to the field. This practice aims to improve soil organic matter levels, reduce soil erosion and improve water conservation.

Reduced fertiliser and pesticides application: Reducing the amounts of nitrogen and phosphorus fertilisers by a certain percentage below the economic optimum will reduce the residual nitrate in the soil after harvest (for leaching) and in the short term the amount of soluble phosphorus. Reducing the input of fertiliser and pesticides will indirectly result in energy savings (and thus reduction of GHG emissions) due to reduction in processing agricultural input.

Grass in orchards and vineyards: Provides seasonal protection of soils through vegetation cover. Additionally it may mitigate soil erosion on slopes, thus increasing soil fertility.

Planting perennial/ permanent crops: Replacing row crops with perennial/permanent crops. The main benefit is improving carbon sequestration potential. This measure may also reduce erosion.

Reintroducing/maintaining terraces: Terraces on platforms, which are built along contour lines in sloping terrains and usually sustained by stone walls, are at risk of abandonment in many agro-ecosystems. The management action is crucial to reduce soil erosion and prevent the formation of gullies.

Grazing land management

Optimising grazing intensity (to avoid overgrazing): Reducing grazing intensity to recover the bearing capacity of soils and grassland habitats, and/or applying the rotational grazing. This practice involves shifting livestock from one pasture to another, so that all grassland species are well grazed and then left to regrow, thus reducing soil erosion and maintaining soil C sequestration.

Length and timing of grazing: Refraining from grazing during wet periods and keeping grazing animals in stables can reduce soil erosion.

Grassland renovation: Actively improving the composition of grassland e.g. by controlled grazing, overseeding and re-seeding, which may reduce soil erosion in some situations, in highly productive systems in particular. The action is inappropriate with regard to soil protection in semi-natural grasslands, where re-seeding and ploughing should be avoided to reduce soil emissions.

Cross-cutting actions (including land use, land use changes and forestry)

Buffer strips: Vegetated and woodland buffer areas are placed around fields and along water courses. They aim to reduce soil erosion or improve water quality, thus positively affecting aquatic habitats. In some instances they could act as green corridors, although their benefit for biodiversity is relatively limited, unless specific management is adopted.

Maintain permanent pasture/ restriction on conversion to arable land: Maintaining permanent pasture or land used to grow grasses or other herbaceous forage that has not been included in crop rotation of the holding for five years or longer. In semi-natural grasslands, occasional ploughing should be entirely avoided to maintain highly valuable carbon stocks.

Conversion of arable land to grassland: May target high risk areas prone to soil erosion for small-scale conversion. This action can involve creating permanent or non-permanent grassland.

Maintaining and restoring wetlands/peatlands and rewetting organic soils: Includes maintenance (eg blocking drainage grips) or creation of wetlands or wet woodland on agricultural land. Wetlands and wet woodlands aim to reduce soil erosion or improve water quality or biodiversity.

Set-aside/ Ecological focus area: Removing land from agricultural production. Land left fallow, terraces, landscape features, buffer strips and afforested areas.

Agroforestry: May involve use of tree cropping, alley cropping, shelterbeds or hedgerows in highly productive agro-ecosystems, which may increase carbon sequestration or decrease wind erosion. Alternatively it supports the maintenance of traditional wooded pastures (dehesas etc.) with high benefits for maintaining carbon stocks, water quality and biodiversity.

Woodland creation: Woodland may be created on agricultural or forest land. Main objective can be reduced soil degradation, enhanced carbon sequestration or improved water quality or biodiversity.

Table 6 highlights the benefits of these soil management actions as they relate to climate change and co-benefits to other environmental priorities. It also identifies potential trade-offs (with environmental and economic objectives) that may emerge from their implementation. The following categories are used to describe the different benefits:

- **Climate and soil related benefits**: addressing soil threats (erosion, degradation, decline in soil organic matter (SOM) and soil fertility, soil structure etc.), carbon sequestration, binding nitrogen etc.
- **Co-benefits for water**: water quality and quantity, infiltration, reduce pesticide leaching etc.
- **Other potential environmental co-benefits**: benefitting biodiversity, reduced pesticide and fertiliser input, increased flood resilience, landscapes etc.
- **Potential cross-sectoral benefits**: pest /pathogen management, crop viability, genetic resources, energy savings, recreational opportunities etc.

Further details on potential obstacles to implementation, technical and environmental limitations as well as cost considerations associated with these practices can be found in the Annex 9 to this study.

Table 6: Overview of key soil management practices, their co-benefits for water management and other environmental objectives

Action	Soil and climate related benefits	Co-benefits for water	Other potential environmental co-benefits	Potential environmental and economic trade-offs	Potential cross-sectoral benefits
Cropland management					
Winter cover and catch crops	Add C to soils, may also extract plant-available N, crop mitigate soil erosion, improve SOM and soil fertility	Improve water infiltration and holding capacity, reduce N, P and pesticide leaching, prevent groundwater pollution	Reduce run-off and nutrient load, provides habitats for species	May decrease nitrogen uptake by following crops and increase soluble P	Benefits crop genetic variability and pest control
Adding legumes or N-fixing crops to rotation or undersowing	Increase in SOM and N-stocks, reduce soil loss		Reduce fertiliser inputs and run-off, benefits biodiversity		Energy savings through reduced mineral fertilizer requirements
Crop rotation	Improve/ maintain soil fertility and structure, reduce erosion, increase SOM and C sequestration	Better water absorption and water holding capacity, reduce pesticide leaching	Provision of more varied habitats and food for species, reduce fertiliser and chemical input and run-off	May affect yields, nitrogen fixation requires water and may lead to less water available for subsequent crops	May decrease build-up of pests in soils
Reduced tillage	Maintain SOM, improves C storage, preserve good soil structure and reduce erosion, protect soil from water logging and drought	Improve water infiltration and holding capacity	Reduction in extremes of water logging and drought, reduce run-off and nutrient loads	Can increase weeds and thus the reliance on chemical control, particularly pesticide use, may increase soluble P	
Zero tillage	Reduced loss of SOM, soil erosion and soil compaction, increased soil nutrient and C storage	Improve water infiltration, conservation and absorption	Improve soil biodiversity	Can increase reliance on chemical control (in part. pesticides), increased denitrification	Energy and cost savings (due to no use of machinery)
Crop residue management	Improve SOM levels, enhance C sequestration	Improve water absorption and conservation	May reduce mineral fertiliser input	Risk of N_2O emissions (from residues with high N-content), may conflict with biomass use for energy	Energy savings (by substituting fertilisers with residues)

Action	Soil and climate related benefits	Co-benefits for water	Other potential environmental co-benefits	Potential environmental and economic trade-offs	Potential cross-sectoral benefits
Cropland management					
Reduced fertiliser and pesticides application	Increase soil organic content accumulation	Reduces threat of leaching and thus water pollution	Reduction in soluble P loss	Depending on crop type may reduce crop yield; can save costs for purchasing fertiliser and pesticides	Energy savings (due to reduced processed agricultural input)
Grass in orchards and vineyards	Reduce erosion on slopes, increasing soil fertility and C sequestration	Improve water filtration rates and thus also water quantity and quality	Benefits pollination through reduced chemical inputs	Increased risk of pests and the depletion of soil moisture; potential competition with crops for water	
Planting perennial/ permanent crops	Improve C sequestration potential and soil structure, reduce erosion	Improve water quality and water holding capacity	Reduce pesticide inputs, can benefit biodiversity, prevent loss of nutrients		Improved production
Reintroducing/ maintaining terraces	Reduce soil erosion and loss of soil organic content	Improve water quality and infiltration, reduce sedimentation	Reduce velocity of run-off, can benefit biodiversity (eg using hedgerows)		
Grazing land management					
Optimising grazing intensity	Reduced soil erosion	Reduce N leaching	Benefits biodiversity		
Length and timing of grazing	Reduced soil erosion	Reduce N and P losses	Benefits biodiversity	Higher use of energy for food and concentrates, higher CH_4 emissions due to stored manure	
Grassland renovation[43]	Increased C sequestration		May benefit (or decrease) biodiversity	May require herbicides, ploughing and harrowing, with loss to biodiversity in semi-natural grasslands	
Cross-cutting actions					
Buffer strips	May reduce soil erosion and carbon sequestration	Reduce water pollution and improve water quality	Benefits biodiversity, improve aquatic environments,	May reduce production	

[43] See also conversion of arable land to grassland

Action	Soil and climate related benefits	Co-benefits for water	Other potential environmental co-benefits	Potential environmental and economic trade-offs	Potential cross-sectoral benefits
Cropland management					
			prevent nutrient run-off, slow down peak flood flows		
Maintain permanent pasture/ restriction on conversion to arable land	Increased C sequestration, reduced soil erosion	Increased water holding capacity	Addresses flooding, reduce use of N and P	Conflict with management for maximum economic profit	
Conversion of arable land to grassland	Reduce soil erosion, increase subsurface storage	Restoring hydrological cycle of drainage basins	Co-benefits to biodiversity, reduce nutrient and pesticide loads, mitigate floods	Conflict with management for maximum economic profit	
Maintaining and restoring wetlands/ peatlands; rewetting organic soils	Reduce soil erosion. maintain C sequestration, reduce GHG emissions	Improve water quality, retain water in ecosystem during dry periods	Improve biodiversity, reduce nutrient and pesticides loads, improve resilience to flooding, provision of habitats and food	Conflict with management for maximum economic profit. For Rewetting: potential loss of productive land and income, may risk CH_4-release in the beginning	
Set-aside/ Ecological focus area	Reduce GHG emissions	Reduces threat of leaching and thus water pollution	Reduced use of pesticides and fertilizers, benefits biodiversity	Conflict with management for maximum economic profit'	Energy savings (due to reduced processed agricultural input)
Agroforestry	Increase C sequestration and decrease wind erosion, improve moisture use efficiency, reduced erosion	Reduce evaporation and plant transpiration rates	Provide food and cover for wildlife		
Woodland creation/afforestation	Reduced soil erosion and degradation, enhanced C sequestration, decrease net GHG soil emissions	Improved water quality, increased water infiltration, reduce run-off	Enhance resilience to flooding, benefit biodiversity, reduce nutrient inputs and surface run-off	Potential negative effects (due to weak design) on groundwater recharge resulting from larger water demands of trees vs. non-irrigated arable crops, loss of productive land	May enhance recreational opportunities

SOM-Soil organic matter, C-Carbon, N-Nitrogen, P-Phosphorous

Sources: Bio Intelligence (2010); Byström (2000); Clement *et al* (2010); European Commission (2011c); Flynn *et al* (2007); Helsinki Commission (2007); Mann and Tischew (2010); Neri (2006); Rubæk and Jørgensen (2012); SoCo (2009a); Söderqvist (2002); Stutter *et al* (2012); Török *et al* (2011)

Based on the different benefits and trade-offs associated with the different soil management actions (presented in Table 6), an overall evaluation of these actions has been prepared and is presented in Table 7.

Table 7: Evaluation of key soil management practices regarding their benefits and trade-offs

Action	Soil and climate related benefits	Co-benefits for water	Other potential environmental co-benefits	Potential environmental and economic trade-offs	Potential cross-sectoral benefits
Cropland management					
Winter cover and catch crops	↑↑	↑↑	↑↑	↓	↑
Adding legumes or N-fixing crops	↑	↑	↑		↑
Crop rotation	↑↑	↑	↑↑	↓	↑
Reduced tillage	↑↑	↑	↑↑	↓	
Zero tillage	↑↑	↑	↑	↓	↑
Crop residue management	↑↑	↑↑	↑	↓	↑
Reduced fertiliser and pesticides	↑	↑↑	↑	↓	↑
Grass in orchards and vineyards	↑↑	↑↑	↑	↓	
Planting perennial/ permanent crops	↑	↑	↑↑		↑
Reintroducing/ maintaining terraces	↑↑	↑↑	↑		
Optimising grazing intensity	↑	↑↑	↑		
Length and timing of grazing	↑	↑	↑	↓	
Grassland renovation[44]	↑	↑	↑	↓	
Buffer strips	↑	↑↑	↑↑	↓	
Permanent pasture/ no conversion to cropland	↑↑	↑↑	↑↑	↓	

[44] see also conversion of arable land to grassland

Action	Soil and climate related benefits	Co-benefits for water	Other potential environmental co-benefits	Potential environmental and economic trade-offs	Potential cross-sectoral benefits
Cropland management					
Conversion of arable land to grassland	↑↑	↑	↑↑	↓	
Maintaining and restoring wetlands	↑↑	↑↑	↑↑	↓	
Set-aside/ Ecological focus area	↑↑	↑↑	↑↑	↓	↑
Agroforestry	↑↑	↑	↑		
Woodland creation	↑↑	↑↑	↑↑	↓	↑

↑↑ Strong co-benefits, ↑ medium or sometimes co-benefits, ↓ trade-offs exist

4.3 Need for public support

The EU Soil Thematic Strategy provides the overall strategic framework for soil protection in Europe. Although far reaching in its goals, it remains limited in impact with no systematic monitoring and protection of soil quality in place (European Commission, 2012d). Moreover, with no overarching legal and policy framework, soil protection is addressed in other policy areas as a secondary objective and most often indirectly. The Good Agricultural and Environmental Condition (GAEC) standards focussed on soil protection under the CAP remain a basic policy instrument on EU farmland. Certain soil management actions assessed in previous sections are often included within the GAEC standards and are therefore part of the environmental baseline. These are intended to be basic management actions that have low cost to farmers (see Section 5). There are a limited number of current GAEC requirements operating in Member States that are specifically focussed on soil organic matter; although many of the requirements for soil cover and soil erosion also help maintaining levels of SOM (Poláková *et al*, forthcoming). Considerable potential exists for Member States to reinforce requirements under the revised GAEC framework in post-2014 CAP. These should address maintaining areas with the soils of low soil organic matter (SOM) that are at risk of complete depletion and the soils with high SOM where the risk of large carbon losses through the decline in carbon content is highest. Soil management actions (and other actions by farmers) that correspond to the baseline requirements are not considered to be environmental public goods meriting support from public budgets (see Box 5). Although the baseline requirements may vary across the Member States, they frequently include some requirements relating to the maintenance of winter plant cover, basic crop residue management and the introduction and maintenance of buffer strips. Member States differ, however, in their approach to including other management actions within the GAEC standards, eg, reduced use of fertiliser and pesticides, basic requirements on optimising grazing intensity and the length and timing of grazing. While in some Member States these soil management actions are included in the GAEC baseline, in others they are part of entry-level agri-environment schemes (Keenleyside *et al*, 2011). The use of public support in the form of agri-environment payments for some of the soil management actions which are very close to the environmental baseline is contentious and cannot be recommended as good policy practice.

Funding from the CAP Pillar 2 is already available to farmers under the agri-environment measure (discussed in detail in Section 5). The measure can support *inter alia* advanced soil management schemes and actions which go beyond the baseline requirements and which can deliver benefits to soil functionality and climate mitigation and adaptive capacity. The baseline requirements are set out under cross-compliance, relevant national legislation on fertiliser and plant protection. The impacts of soil management actions which merit public funding should be demonstrably beyond 'what would have happened anyway' (see Section 5). A range of more advanced soil management actions identified in Section 5.2 would help deliver such environmental public goods and can receive support through the agri-environment measure. The integration of the climate priority in the proposed post-2014 Pillar 2 funding, in particular the revised agri-environment-climate measure, will reinforce the opportunity for funding advanced soil management[45]. The relevant soil management actions can include:

- More advanced crop rotations with fellow or legumes or N-fixing crops;
- More advanced residue management;
- No or reduced fertiliser and pesticides application;
- Reintroducing and maintaining terraces;
- Conversion of arable land to grassland;
- Maintain permanent pasture and restrict the conversion to arable land; and
- Maintaining and restoring wetlands, peatlands and rewetting organic soils.

Other practices identified in the section above, such as afforestation and agroforestry, have been already supported under the rural development policy in the 2007-2013 period (and before) through specific measures, which are expected to be applied in the next programming period too[46] (Section 5.2.1). All the above mentioned funding measures may be combined with support through advisory services, training, and information and non-productive capital investments on farms (Section 5.2.2). This type of support is also planned to be continued in the post-2014 CAP[47].

Certain types of soil management practices, for example reduced use of fertiliser and pesticides, limited grazing intensity and management actions to protect semi-natural grasslands, wetlands, peatlands and floodplains may be required from farmers by the management plans for Natura 2000 sites under the Habitat and Birds Directive and by the Water Framework Directive. In these situations, the dedicated payments have been provided under the 2007-2013 rural development policy (Section 5.1) and are foreseen to be applied in 2014-2020[48]. Support to organic farming will also continue according to the proposed revision of the CAP Pillar 2 in the 2014-2020 programming period[49].

4.4 Recommended options

Previous sections demonstrated that soil management is essential for the management of natural resources associated with European agriculture, maintaining soil quality and supports protection of water resource. While agriculture is one of the key drivers influencing the state of Europe's soils in both positive and negative ways, improved soil management can provide direct benefits to soils,

[45] Article 29 (agri-environment-climate) in the proposed EAFRD Regulation COM (2011) 627/3, under negotiations with the European Parliament and the Council.

[46] Article 23 (afforestation and creation of woodland), Article 24 (establishment of agroforestry systems) and Article 22 (investments in forest area development and improvement of viability of forests including agro-forestry) ibid.

[47] Article 15 (Knowledge transfer and information actions), Article 16 (advisory services and farm management), and Article 18 (Investments in physical assets) ibid.

[48] Article 32 (Natura 2000 and WFD payments) ibid.

[49] Article 30 (Organic farming) ibid.

climate change mitigation and adaptive capacity, and indirectly to water and biodiversity, with considerable potential co-benefits to productivity and farm revenues. There are a large number of policy options for improved soil management put forward in recent literature (Frelih-Larsen *et al*, 2008; Gobin *et al*, 2011; Poláková *et al*, forthcoming). Some of them may have a greater potential to get implemented in practice than others. The limiting factors can include:

- Technical implementation;
- Costs of implementation;
- Administrative burden;
- Acceptance on behalf of policy makers;
- Degree of likely uptake of the option by the target group; and
- Further research is needed.

Further limiting factors, which are more difficult to assess are the political will and coherent governance between multiple actors presenting different interests. Based on the assessment in this section, four priority options are recommended and several supporting options. Table 8 provides their overview.

Table 8: Options for incentivising sustainable soil management

Priority options	Initiated/implemented by whom	Urgency
Promoting sustainable soil management practices through appropriate policies	European Parliament, national and regional authorities, management authorities, advisories, farmers, academics	Short to medium term
Strengthen soil management requirements in the GAEC framework and introduce EU-wide framework for soils	European Parliament, national and regional authorities, management authorities, advisories, farmers, academics, advisories.	Short term[1]
Adopt good practices for identifying soil risks at regional and local levels across the EU	National and regional authorities, farmers, academics, private businesses.	Medium term
Establish routines for climate-proofing relevant regional and national programmes	National and regional authorities, management authorities, payment agencies, NGOs and others	Short term[1]
Supporting policy options		
Integrate sustainable soil management actions in climate adaptation strategies and river basin management plans		
Develop customised decision support tools and disseminate guidance documents		
Develop payments for ecosystem services and promote public-private partnerships		
Raise public awareness of the relevance of soil management to tackling climate change		
Address consumption habits by examining the potential of certification schemes and labels to account for soil impacts in a coherent manner.		

Note:

1. Urgent action is needed in relation to the guidance to Member States since the programming is in advanced phase.

As indicated in Section 2, the Commission Blueprint to Safeguard Europe's Water Resources provides a suite of policy recommendations focussed on water benefits. Recommendations identified in this study are complementary to the Blueprint which contains the actions for improved land use, recognised as one of the pressures affecting the ecological status of Europe's water bodies. However, the Blueprint focuses on EU level only. By contrast options recommended here also address potential actions to be taken at national and regional levels. They include:

- **Priority option 1: Promoting sustainable soil management practices**

Combating soil erosion, preventing loss of soil organic matter and sequestering soil carbon should be promoted at EU, national and regional levels. Two specific types of management approaches are critical. Firstly, consistent enforcement of permanent vegetation cover would be highly effective in combating erosion and should be more fully enforced through the good agricultural and environmental condition (GAEC) framework. Secondly, the maintenance and restoration of wetlands, wet meadows and floodplains has valuable benefits for natural water retention, habitats and climate regulation where these actions take place on peat soils. Due to economic costs, these actions critically depend on agri-environment-climate support under the CAP, LIFE+ and national funds. Several other beneficial soil management actions, such as more complex crop rotations, intercropping of legumes or other N-fixing crops and reduced tillage can be promoted by agri-environment schemes where they go beyond the baseline requirements. Dissipation of large amounts of agri-environment-climate budgets on basic soil management practices should be avoided. Direct advice provision to the farmer from a well-trained adviser would allow for recommending effective management practices tailored to specific soils (See Section 5.4). Decision support tools, including soil maps, graphs and tables based on the farm's area, soil type, and current management practices (discussed below), could also assist in identifying appropriate management practices.

- **Priority option 2: Strengthen soil management requirements in the GAEC framework and introduce an EU-wide framework for soils**

There are a limited number of current GAEC requirements operating in Member States that are specifically focussed on soil organic matter (SOM), although many of the existing requirements for soil cover and soil erosion may help maintain SOM levels. Strengthened requirements are needed in particular to address maintaining areas with the soils of low SOM that are at risk of complete depletion and the soils with high SOM where the risk of large carbon losses through the decline in carbon content is highest. The reinforced GAEC standard for SOM should be retained in the revised framework as currently proposed, and the GAEC for the protection of carbon rich soils should be re-instated. Since land and soil management often has important co-benefits for water retention in soils and the water infiltration capacity of soils, the adoption of an EU-wide framework for soils, eg, through the Soil Framework Directive, is an urgent priority.

- **Priority option 3: Adopt good practices for identifying soil risks at regional and local levels across the EU**

Priorities for soil management depend on identifying places where actual soil risks occur. Several approaches exist for identifying locations with soil risks, but they are not applied everywhere or sometimes inappropriate methods are used. There is a need to develop the technical capacity and decision support tools to identify such areas, such as maps and soil inventories, incorporating local knowledge on nutrient levels and soil structure as well as scientifically validated sustainability indicators. These tools may then be used to target soil management schemes to the specific soil needs (determined through need analysis) in the identified risk areas.

- **Priority option 4: Establish routines for climate-proofing relevant regional and national programmes**

Climate-proofing regional and national programmes and strategies (for several sectors in addition to agriculture and rural development such as industry, forestry, energy, business, or tourism) is a proactive approach to assessing the potential impact of soil management on climate change mitigation and adaptation. Avoiding environmental damage and repair, inappropriate investment, and increased need for emissions reductions would likely outweigh the costs of such proofing measures. Integrating them into the regular cycle of programming rather than creating a separate task would maximise efficiency and avoid additional administrative burden. Moreover, ensuring that funding is allocated to effective land and soil management would prevent inefficient use of financial resources.

- *Supporting option: Integrate sustainable soil management actions in climate adaptation strategies and river basin management plans*

While climate adaptation strategies at all scales (from national to municipal) should integrate soil protection measures to improve the resilience of soils and thus the adaptive capacity of farms, river basin management plans should integrate land-based measures to promote improvements in water quality. It is likely that a good deal of synergies for water, soils, climate change mitigation and improved adaptive capacity of agro-ecosystems can be developed through the integration of sustainable soil management schemes into these strategies at appropriate territorial levels. Such action will improve policy coherence. These strategies need to be tailored to local conditions. In addition to helping maintain food productivity in the face of climate change, sustainable soil management practices could provide a number of co-benefits (eg, resilience of ecosystems, nutrient cycling, reduced erosion and runoff) and civil protection (eg, reducing water flows and flooding, increasing water retention thereby necessitating less irrigation)

- *Supporting option: Development of customised decision support tools and disseminate guidance documents*

Information and contextual recommendations on soil management practices beneficial for climate change mitigation and adaptation should be available in the form of decision support tools (DSTs). The DSTs could produce soil maps, graphs and tables highlighting eg soil trends and threats or soil risk areas. This information could be combined with a carbon calculator to model the effects of different management practices on carbon sequestration and mitigation potential at farm level. Such a tool can also provide information on the cost-effectiveness of the different management practices also addressing benefits to productivity. In addition, provision of guidance to land users, decision-makers, and sectors dependent on or influencing soil use is needed. The potential of farm advisory is discussed in Section 5.4. Regional and local policy-makers (eg, working in the urban and planning context) also need guidance for incorporating soil management concerns into their decisions.
Business and industry would benefit from guidance on best practices, certification schemes and supply chain incorporation of products from sustainable soil management practices.

- *Supporting option: Develop payments for ecosystem services and promote public-private partnerships*

What Payments for ecosystem services (PES) have the potential to incorporate soil management schemes designed at the local or regional catchment level, and to target simultaneously benefits for soils, water quality, flood prevention and biodiversity. PES schemes can provide positive incentives to land users to adopt recommended practices on the priority soils in identified risk zones. However, there are certain methodological issues relating to monetarism of ecosystem services that still need development. Opportunities for public-private partnerships (PPP) and direct interactions between farmers (as the provider of ecosystem services through sustainable management) and the sectors benefitting from those (eg tourism, water supplier) need to be explored and promoted more strongly. Establishing good practice examples for PES and PPP in Europe (underpinned by cost-benefit analysis) can help to encourage regional and national policy-makers as well as business to invest in such schemes.

- *Supporting option: Raise public awareness of the relevance of soil management to tackle climate change*

Policies targeted toward raising public awareness of soil management's potential role in climate change adaptation and mitigation provide a low-cost, potentially high-benefit option. Emphasising the role soil management could play in mitigating emissions and carbon sequestration, policy-makers in the Member States should be made aware that failure to reduce emissions from the agricultural sector would increase the amount of reductions necessary from other sectors at higher costs. Awareness raising could also target actors who have an impact on the soil through sourcing land-based products and consumers, pointing to possible negative effects from poor soil management, such as supply chain disruption, resource scarcity, increasing food prices and continuing water quality degradation.

- *Supporting option: Address consumption habits – assess the potential of certification schemes to promote sustainable land management*

In order to promote the uptake of sustainable soil management practices, and therewith addressing soil fertility, climate, but also further environmental impacts of food production, consumption patterns have to change. In addition to information and awareness raising campaigns, product labels (based on certification schemes) can indicate the climate and environmental of products can and thus help to stimulate more sustainable consumer choices (see Section 5.5). Rather than establishing new labels (eg for carbon labelling), existing labelling systems should be revised to take into account climate-friendly soil practices. The organic farming regulation could be enhanced to include climate-related requirements.

5 CAP MEASURES FOR IMPROVED WATER AND SOIL MANAGEMENT

This section considers the measures available under the Common Agricultural Policy (CAP) in the 2007–2013 programming period for improved management of water and soil resources. First, it sets out the range of CAP measures directly or indirectly focussed on water benefits, while marking their potential benefits to soils (Section 5.1). It then assesses the impact and effectiveness of the most relevant measures within CAP Pillar 2, with an emphasis on the agri-environment measure, Pillar 1, and various incentives outside the CAP (Sections 5.2 to 5.5). The principles of the effective use of the CAP funds are set out in Section 5.6. To conclude, we present the recommended options for incentivising sustainable management of water and soil through the CAP (Section 5.7).

5.1 Introduction

Increasingly since the 1990s water and soil issues have grown as a priority in the CAP adding to the priorities of landscape and biodiversity that had been the initial focus of agri-environment measures in countries such as France, Germany and the UK in the 1980s. The Nitrates Directive, introduced in 1991 alongside the agri-environment measure under rural development policy have been the policy instruments that have had the most significant impact in reducing the impact of agriculture on water quality. As mentioned before, the Sustainable use of Pesticides Directive and Water Framework Directive should play an increasingly important role in the near future.

Many CAP measures have the potential to deliver water and soil benefits but not all of them set this out as their core objective (Cooper *et al*, 2009). Currently, cross-compliance and the agri-environment measure are critical for ensuring these benefits. However, a whole range of other CAP measures can also be used. Table 9 presents measures focussing on water. The majority of measures identified can possibly targ*et al*so soil objectives. As mentioned in the introduction, some of the measures discussed in this section may change after 2014. For example it is proposed that new 'greening' measures are incorporated in Pillar 1, restrictions are placed on certain Pillar 2 measures, and Article 68 schemes are proposed to be discontinued[50]. Other key shifts that are expected after 2014 are indicated in Section 5.6.

Table 9: Overview of CAP measures focussed on water benefits (2007-2013)

Measure	Measure Description	Focus Direct (D) - Indirect (I)
Pillar 1		
Cross compliance – SMRs and GAEC[51]	Conditions placed on the receipt of decoupled direct payments and agricultural area based payments under Pillar 2	D, I
Article 68 of Council Regulation 73/2009	Special support for : • Specific types of farming which are important for the protection of the environment - art. 68 (1)(a)(i) • Specific agricultural activities entailing additional agri-environment benefits - art. 68 (1)(a)(v).	D

[50] However, elements of support currently possible under Article 68 will continue under different guises – eg voluntary coupled support in Pillar 1 and income stabilisation measures under Pillar 2.

[51] Council Regulation (EC) No 73/2009 of 19 January 2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers.

Farm Advisory System	Obligations regarding advice on cross-compliance under articles 12 and 13 of Regulation 73/2009[1]	I
National Frameworks for Fruit and Vegetables[52]	Actions aimed at protection of water – Art. 3 (b), Art. 20 (c)(vi)	D
Pillar 2[53]		
Axis 1		
111, 114, 115	Training, information and advisory measures	I
121	Farm modernisation	I, D
123	Adding value to agriculture and forestry products	I
125	Infrastructure for agriculture and forestry	I, D
Axis 2		
211, 212	Natural handicap payments	I
213, 224	Natura 2000 payments and WFD payments	D
214	Agri-environment payments	D
216, 227	Non-productive investments	D
221, 222	First afforestation and first establishment of agro-forestry systems on agricultural land	D
Axis 3		
321	Basic services for the economy and rural population	I
322	Village renewal	I
323	Conservation and upgrading of the rural heritage	I
Axis 4		
411-414	Leader approach	I
Other CAP measures		
Organic farming[54]	Actions aimed at maintenance, enhancement, protection and responsible use of water and soil	D
SAPARD, IPARD[55]	Agri-environment (D); actions to support (D), improvement and development of rural infrastructure (I)	D,I

Note: The analysis has been carried out for water benefits only.

[52] Council Regulation (EC) No 1182/2007 of 26 September 2007 laying down specific rules as regards the fruit and vegetable sector.

[53] Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). The post-2014 successor instrument is set out in Proposal for a Regulation of the European Parliament and of the Council on support for rural development by the European Agricultural Fund for Rural Development (EAFRD), COM(2011) 627/3.

[54] Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. Support to the conversion and maintenance of organic farming is provided under the agri-environment measure within Pillar 2.

[55] Council Regulation (EC) No 1268/1999 of 21 June 1999 on Community support for pre-accession measures for agriculture and rural development in the applicant countries of central and eastern Europe in the pre-accession period; Article 12 of Council Regulation (EC) No 1085/2006 of 17 July 2006 establishing an Instrument for Pre-Accession Assistance (IPA).

5.2 CAP Pillar 2 measures

This section summarises the measures aiming to mitigate challenges to water availability, water quality, and management of water flows in river basins within RDPs in the 2007-2013 programming period. Member States outlined such challenges to water in their needs assessment in preparation of RDPs and linked them to actions and measures proposed. All these measures are underpinned by relevant legislation and cross-compliance. Table 10 provides an overview of the range of management actions for the achievement of sustainable outcomes for water based on a review of 88 RDPs[56]. Subsequent sections provide information on the impact and effectiveness of these actions in more depth, whilst grouping them under Pillar 2 measures that have a direct focus (Section 5.2.1), those which have an indirect focus on water (Section 5.2.2) and cross-cutting measures (Section 5.2.3).

To understand the scope of support available to water and soil actions from Pillar 2, it is also important to consider the types of measures available according to the ways in which they are implemented. The measures can be thus classified into several types:

- Incentive payments for land management actions or compensation for constraints to management;
- Capital investments in agricultural, forestry or environmental infrastructure in wider rural areas;
- Adding value to environmentally sustainable produce; and
- Training, advisory, information and extension services.

With regard to the RDP budg*et al*located to water priority in the 2007-2013 period, its structure does not allow for breaking it down to allocations to specific environmental issues. Available data provide information only on the funds allocated to the 'new challenges', including water, as a result of the CAP Health Check in 2009. These data demonstrate that water management was the focus of the second largest proportion of additional funds (27 per cent) which is on the scale comparable with the largest additional allocation concentrated on biodiversity (31 per cent).

Table 10: Types of management actions with the potential to deliver water benefits within the 2007-2013 RDPs

Types of management actions	RDP measures	Water benefits
Water use and water availability – capital investments on farm		
Water saving technologies Water storage Farm reservoirs	• Farm modernisation (121) • Infrastructure related to agriculture and forestry(125)	Use water efficiently Improve the capacity to store water

[56] The review by ENRD, 2010a and 2010b preceded the implementation of the changes introduced by the CAP Health Check. The information is indicative and does not reflect results of allocating additional funds to 'new challenges' including water by Member States. However, the basic typology of actions in RDPs is likely to have remained largely the same.

Water use – land management actions		
Water saving soil management Conversion of irrigated cropping to extensive dryland cropping	• Agri-environment payments (214)	Improve soil capacity to retain water
Water quality – capital investments on farm		
Manure, slurry, fertiliser, and silage handling/processing/storage Improvement to livestock housing and handling areas Limiting access of livestock to rivers and streams Waste water treatment on farms, in processing and marketing	• Farm modernisation (121) • Adding value to agriculture and forestry products (123)	Protect and improve water quality
Water quality – capital investments in wider rural areas		
Waste water treatment plants in rural areas	• Basic services (321) • Village renewal (322)	Protect and improve water quality
Water quality – land management actions		
Riparian buffer strips Field margins Other management actions to reduce run-off	• Natura 2000 and WFD payments (213) • Agri-environment payments (214) • First afforestation of agricultural land (221)	Reduce nutrient run-off Protect and improve water quality
Soil management actions Organic farming Integrated management	• Agri-environment payments (214)	Protect and improve water quality
Management of water flows – land management actions		

Wetland creation Wetland restoration Wetland management	• Agri-environment payments (214) • Non-productive investments (213)	Maintain stable water tables Protect and improve water quality Slow down and reduce peak floods
Management of water flows – land use change actions		
Conversion of arable land into permanent pasture Conversion of agricultural land into forest and agro-forestry	• Agri-environment payments (214) • First afforestation of agricultural land (221)	Maintain stable water tables Protect and improve water quality Slow down and reduce peak floods
Management of water flows – capital investments		
Small watercourse restoration Wetland creation and restoration	• Non-productive investments (213) • Village renewal (322) • Conservation of the rural heritage (323)	Restore semi-natural beds, banks and meanders of small water courses Slow down and reduce peak floods
Cross-cutting actions		
Training, information and advice Farm management plans and record keeping	• Training, information and advice measures (111, 114, 115) • Agri-environment payments (214)	Increase awareness about efficient water use, impacts of land management on water
Participatory approaches	• LEADER	Opportunities for group action across holdings within a catchment

Whether or not support under Pillar 2 measures actually results in more sustainable water use, improved water availability and water quality, better management of water flows or improved soil management will depend on the degree to which the measures deliver the intended effects in practice. However, data available on the effectiveness of these measures are limited and tend to be prospective in nature (Kleijn *et al*, 2006; Kleijn and Sutherland, 2003; Sahrbacher *et al*, 2005; Brady *et al*, 2009; Schmid *et al*, 2010). Also, disentangling the specific water and soil impacts of specific CAP measures from the effect of wider agricultural trends on water and soil is not a small task. This is due to the varied ways in which different farming systems within Europe react to signals from different policy instruments (Baldock *et al*, 2002; Lillunen *et al*, 2011) and a range of exogenous factors such as the prices of commodities and inputs, technological developments and market requirements. The information that we set out to find focusses on actual water impacts and relates mostly to several Pillar 2 measures. Information on soil impacts per se has not been collected. No data are available on the impacts of cross-compliance and Article 68 schemes in Pillar 1. Sections below summarise the available information.

It is important to note that besides the CAP measures; there are other sectoral policies that affect water use and water quality in river basins associated with agro-ecosystems. A notable example is the Renewable Energy Directive (RED) targets which influence the demand for biofuel feedstocks (including grain and oil-seed crops) (Hart *et al*, 2013)[57]. However, the RED provides no further mechanisms beyond CAP cross-compliance to minimise pressures to natural resources from the feedstock cultivation. Evidence demonstrates that water intensity of biofuel feedstocks is several orders of magnitude higher than that of other energy carriers, therefore they pose important risks to both the water resource in the areas in which they are cultivated (EEA, 2006). The risks vary greatly in relation to the type of crop and the farming systems in which it is produced. A recent study by the European Commission concluded that the goal of achieving additional output from agriculture may lead to increase in areas under irrigated agriculture, intensification of existing production through increased inputs or irrigation, and the removal of residues (such as straw) from the field. The net risks to the water resource therefore are expected to increase as biofuel output increases and as agricultural systems are integrated or optimized to avoid the effects of displacing EU production to third countries (Diaz-Chavez *et al*, 2013).

5.2.1 Pillar 2 measures with a direct focus on water

Agri-environment measures

Member States can use the agri-environment measure to introduce schemes and management actions that reflect different bio-physical, climatic, environmental and agronomic conditions across the EU and to adapt management to suit the particular combination of water needs which may be extremely varied even within one region (Keenleyside *et al*, 2006; OECD, 2010). The measure is frequently used together with non-productive investments (216). All agri-environment schemes must go beyond the minimum level of management set out in cross compliance (for details see Section 5.2.1) and the minimum requirements for fertiliser and plant protection product use. These requirements are set out in national legislation[58]. Among others they must include the Codes of Good Practice introduced under the Nitrates Directive for farms outside Nitrate Vulnerable Zones[59], and requirements

[57] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, OJ L140/16, 05/06/09. The Directive currently mandates 10 per cent renewable energy in the transport sector by 2020. In 2012, the Commission has put forward proposals to limit the first generation crop-based biofuels to five per cent of transport fuel consumption (which is approximately the current level of usage) and the remaining 5 per cent to achieve the 10 per cent 2020 target is to be met by using wastes and agricultural and forest residues rather than agricultural crops. (Proposal for a Directive of the European Parliament and of the Council amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources, COM (2012) 595. This proposal is under negotiation with the European Parliament and the Council.

[58] Article 39 of Council Regulation (EC) 1698/2005.

[59] Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, OJ L 375, 31.12.1991.

concerning phosphorus pollution. With regards to plant protection products, they must include national requirements on the licence to use the products, training, safe storage, checks of machinery and pesticide use close to water and other sensitive sites. In the revised CAP, the measure is expected to shift its focus to integrate the climate change priority60. The interaction of the revised measure with the revised Pillar 1 will result in significant changes in relation to the environmental baseline. This leads to a renewed emphasis on the basic principles for the effective use of funds for land based actions in particular (Section 5.6).

Within the CAP the agri-environment is the most important measure for fostering environmental management which goes beyond the reference line. Its significance is due to the budg*et al*located to the measure, its compulsory nature and the fact that it is the only measure which allows support for targeting and tailoring land management to specific needs. However, it is only recently that Member States have developed agri-environment schemes directly focussing on water and soil, or schemes with multiple objectives including water and soil, alongside the more traditional biodiversity objectives[61]. Therefore, the agri-environment measure has been only complementary so far to the key measures that address agricultural water pollution under the Nitrates Directive[62]. The total budg*et al*located to this measure in the 2007–13 programming period amounts to €38 billion (including national co-financing) which accounts for almost a quarter of all planned EAFRD expenditure for 2007-13. It is estimated that over 35 million hectares will be brought under successful management relating to water quality, accounting for 21 per cent of utilised agricultural area, but the estimated outcomes of such management for water quality in practice are unclear.

In the 2007-2013 RDPs, agri-environment management actions focus on water benefits either directly or indirectly. Annex 10 provides an overview of the prioritisation of the types of water actions in the 2007-2013 RDPs, their geographic usage as well as their potential co-benefits and conflicts with other environmental objectives.

The agri-environment schemes that aim to deliver benefits to water quality typically include management actions listed below. An analysis of 88 RDPs looking at their objectives, priorities and measures proposed, showed that water quality was directly targeted in more than half of RDPs (ENRD, 2010a)[63]. Several RDPs including four in Spain do not identify water quality as a priority at all. The relevant management actions involve:

- Input reduction to reduce nutrient and pesticide run-off, eg no spray zones within arable fields;
- Establishment or maintenance of riparian buffer strips;
- Establishment of field margins;

[60] Article 29 in the proposed Regulation of the European parliament and of the Council on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) COM(2011) 627/3, under negotiation with the European Parliament and the Council .

[61] AE schemes focussed on reduced use of fertiliser and pesticides were often introduced to achieve biodiversity objectives and were not often targeted to water quality per se. Schemes for aimed at improvements in water availability are very recent.

[62] It is expected that land management actions under the Water Framework Directive, formally implemented since 2012 but delayed in a number of Member States, would provide additional basic benefits to water availability, water quality and management of water flows in river basins.

[63] The background analysis was carried out in early 2010 and is outdated, reflecting the status of RDPs preceding the implementation of the amendments resulting from the CAP Health Check in 2009. However, more recent information is not available.

- Maintenance of landscape features ;
- Introducing or maintaining extensive arable management;
- Introducing or maintaining extensive grazing practices;
- Introducing legumes in crop rotations;
- Establishment of grassed waterways, run-off furrows; and
- Creation, restoration or maintenance of wetlands.

Only a few agri-environment schemes in the current RDPs target water availability directly. This is partly due to the fact that this priority is commonly addressed by capital investments in infrastructure under other Pillar 2 measures. Additionally, some management actions for water quality or management of water flows in river basins may have indirect benefits for water availability. See Section 4 for the discussion of such synergies. Examples of actions directly targeting water availability in RDPs are:

- Water saving management actions (catch crops, cover crops);
- Reducing water use on existing crops; and
- Reversion of irrigated cropping to extensive dryland cropping.

Management of water flows in river basins is targeted by agri-environment schemes often involving other objectives, such as water quality and biodiversity:

- Creation or restoration of wetlands (including seasonal flood meadows and washes);
- Maintenance of wetlands;
- Reversion of arable land to grassland; and
- Establishment of hedges/lines of trees at 90 degrees to slope.

Within agri-environment schemes where the direct objective is stated to be the delivery of soil benefits, or in schemes with multiple objectives, some management actions may have strong knock-on benefits for water. They involve:

- Soil management (minimum or no tillage, green winter cover, over-winter stubbles, green cover under permanent crops as discussed in detail in Section 4);
- Introduce or maintain organic farming practices; and
- Introduce or maintain integrated management.

Cross-cutting actions in many agri-environment schemes are often of high importance for delivering water benefits. These include requirements to put in place farm management plans and maintain records. A range of recent studies highlight the benefits of using plans for nutrient management, soil management and whole farm environment management alongside the application of agri-environment funds (Dworak *et al*, 2009; ENRD, 2010b, SoCo, 2009b; BIO Intelligence, 2012). However, drought management plans, presented as a promising option in Section 3, have not been so far included in RDPs. Training and information actions are an effective flanking measure to agri-environment schemes, discussed below in Section 5.2.3).

The evidence on the actually delivery of agri-environment schemes is limited due to the range and complexity of objectives, limited data on the baseline conditions and the counterfactual (Hart and Baldock, 2011). Since many of the factors affecting the results of a scheme are specific for the particular region for which the scheme was designed, management that is effective in one Member State or in experimental conditions needs testing and process of adjustment to local conditions prior to its implementation in another Member State or on a farm (Kleijn *et al*, 2004; Kleijn and Sutherland, 2003;

Kleijn *et al*, 2006; Ohl *et al*, 2008; Lillunen *et al*, 2011). Where the expected benefits of a scheme do not materialise in practice, some requirements may need changing (Nemes, 2011; Poláková *et al*, 2011; Lillunen *et al*, 2011). Also it has been observed that there is a limited range of indicators to measure the impacts of RDPs or specific measures on water at the EU level (both under the Common Monitoring and Evaluation Framework (CMEF) and Eurostat/EEA agri-environmental indicators). Often Member States do not include additional indicators on water issues within their RDPs either (European Court of Auditors, 2011). An example of good indicator practice is the RDP in Aragon-Spain which incorporated additional measurement for actual water saving in the measure for water infrastructure, alongside EIA and monitoring provisions in order to guarantee net water benefit (Boccaccio *et al*, 2009). In other RDPs which include additional indicators, they are too often not specific enough or have no link with the relevant pressure (European Court of Auditors, 2011).

The most frequently supported management actions of all the above agri-environment priorities are those that incentivise the delivery of benefits for water quality within intensive systems. For example the establishment of riparian buffer strips is supported in about one third of RDPs within the basic schemes, and the establishment of no spray zones within arable fields and other management actions to reduce nutrient input in almost half of RDPs. Over a quarter of RDPs expects benefits to water quality from the introduction of extensive arable management (Dworak *et al*, 2009; ENRD, 2010a). Box 13 below provides an overview of some relevant management actions and their effects. In addition to such targeted management actions, actions targeting other objectives and indirectly benefitting water quality are included in the majority of agri-environment schemes across RDPs. Important for water quality are also benefits delivered through organic farming which is supported through agri-environment schemes within all 2007-2013 RDPs. These benefits are further discussed in Section 5.4.

Box 13: Examples of schemes aimed at water quality supported through the RDP agri-environment measure

Buffer strips

Land management in the Dommel and Warmbeek river basin in Belgium resulted in fertiliser and pesticide run-off into the river. In order to prevent further water pollution, natural buffer zones were created under the agri-environment scheme in seven municipalities of Limburg. The main objective was to improve water quality, protect the biodiversity of the river basin and at the same time stimulate cooperation amongst farmers and the local authorities in an effort to demonstrate how such outcomes could be achieved elsewhere. The project was successful in both water protection and enhanced cooperation. Buffer strips in Greece are commonly grouped in packages with actions related to soil and water protection. One particular package required farmers to create buffer strips on at least five per cent of their land and to reduce the use of fertilisers by 30 per cent. These actions aimed to mitigate water pollution from nitrates. For this purpose 25 per cent of potentially irrigable land was to be taken out of production, whilst 20 per cent of the irrigable land was to be put into rotation every five years. A package in Denmark specifically targeted the creation of buffer strips of 10-20m, adjacent to lakes and watercourses. In much different farming systems in Estonia, smaller buffer strips were deemed sufficient (2-5m), along with requirements to rotate crops, apply specified seed varieties, and produce a management plan and keep records. In England, resource protection is addressed through entry-level schemes and is likely to benefit from about 25 per cent actions offered to farmers under these schemes. Half of such actions require the establishment of buffer strips. Evidence demonstrates that reduction in direct pesticide run-off to watercourses is proportional to the width of buffer strip, thus its success is very much linked to size, nature and location. Resource protection measures accounted for 25 per cent improvement in biological condition of streams and small rivers in England between 1990 and 1998, with deterioration noted on only 2 per cent of sites.

Crop rotations

An agri-environment zonal scheme in Castro Verde, Portugal, provides support for low intensity farming, traditional crop rotation, low stocking densities and restricted pesticide use. These measures are directed primarily at protecting steppe birds, but have indirect positive effect on water quality. In France, the assessment of crop rotation on farming systems, crop succession and agricultural management showed in 2006 that the use of the agri-environment measure led to more diversity and higher share of land under crop rotation, reduced fertiliser use and improved weed management. Scientific evidence demonstrates that the use of crop rotations, including areas of fallow land within the rotation, is associated with lower levels of chemical inputs, thereby reducing the risk of water pollution, as well as providing habitats for birds, insects and small mammals.

Source: adapted from Bio Intelligence, 2010; Keenleyside *et al*, 2011; ENRD, 2012; Boatman *et al*, 2008; Countryside Survey, 2000.

Ample evidence exists to demonstrate the beneficial effects of agri-environment schemes on reducing the use of fertilisers and pesticides on arable land implemented from the 1990s to 2010 (Primdahl *et al*, 2003; Natural England, 2009; Boatman *et al*, 2008). Differences were found between the performance of farmers with agri-environment agreements which included such requirements for reduced use of inputs and the rest of the farmers. For example in the group of the agri-environment farmers with such contracts in the 1990s, improvement of nutrient management was shown to be twice as high as by the rest of the farmers (35 compared to 16 per cent). More than half of the agri-environment farmers with such contracts have made improvements in reducing fertiliser and pesticide use, while only one out of ten of other farmers made such changes. Although clear improvements were found in fertiliser and pesticide use on arable farms, it was not possible to establish the effects on water quality within the same time period (Primdahl *et al*, 2003).

Many mid-term and ex-post evaluations of effectiveness of agri-environment schemes that operated over the period 2000-2006 also recognised beneficial effects on wider water quality, although they could not measure agri-environment impacts on water at farm level. Improvements in water quality may take a long time to be visible (up to 40 years in some underground aquifers) so in the 2000-2006 period studies could not observe these effects directly (Oréade-Brèche, 2005). Indirectly, evaluations of RDPs in Germany noted progress in reducing fertilizer and pesticide pollution, whilst for RDPs in Sweden, the Netherlands and Spain they demonstrated a positive impact on ground and surface water quality (EPEC, 2004). However, the European Court of Auditors questioned the validity of payments for fertiliser reductions given the difficulties of measuring the direct impacts of these payments (European Court of Auditors, 2005). In some other cases the effect of a potentially well-designed scheme was undermined by a low uptake, for example in France it was noted that schemes addressing diffuse water pollution had low uptake by farmers in intensive regions since they involved a change in management that was felt to be too demanding (European Court of Auditors, 2011).

The agri-environment measure plays an important role in the support for the creation, maintenance and restoration or wetlands. The measure supporting **non-productive investments** on agricultural land (216) is often used alongside the agri-environment. The maintenance and creation of wetlands has the potential to enhance the management of water flows in river basins, for example reduce flooding and increase low flows, and act as filters for nitrate run-off, with co-benefits for mitigating soil erosion. Wetlands also provide other ecosystem services (CBD/UNEP, 2012). In some situations

the newly created wetlands may compensate the previous habitat loss and improve living conditions for birds (European Commission, 2007a; Dworak *et al*, 2009). However, so far there has not been sufficient integration of flood management and biodiversity protection in these schemes. This has to improve particularly where both objectives were intended to be addressed at the same time (Boatman *et al*, 2008). Agri-environment funds have been used to restore and maintain degraded wetlands characteristic of some of the most valuable semi-natural and natural habitats of Europe. Successful examples include the restoration of blanket bogs, moorlands, wet and floodplain grasslands and associated landscape features. In the schemes addressing the restoration of blanket bogs, the agricultural factors that caused their degradation in the past were addressed as the principal issue. Such factors involved for example drainage, heavy grazing and inappropriate afforestation (BRIG, 2008). Some but not all agri-environment schemes for wetland restoration include a requirement for a site-specific need assessment, which is critical in designing the packages of actions that would in practice achieve the desired impact (Boatman *et al*, 2008). Such assessments take account of factors including soil type, nutrient status and wetness, management history, location of semi-natural features etc (BRIG, 2008).
Box **14** provides examples of relevant agri-environment schemes funded through RDPs.

Box 14: Examples of schemes aimed at management of water flows supported through the RDP agri-environment and non-productive investment measures

In **Italy**, support for non-productive investments (216) was used to restore wetlands in the Po Valley. The key objective was biodiversity protection in High Nature Value farming systems, together with the enhancement of water quality. The scheme was also expected to improve soil characteristics compatible with the cultivation of rice and restore landscapes.

In **England** the agri-environment measure (214) was used to restore Walmore Common, an important Ramsar wetland with geological and ecological heritage. The scheme employed an integrated local delivery model to empower the local community and delegate collective responsibility in managing the area. The main actions included water level management. The scheme succeeded in delivering a landscape scale process accompanied by good water management of designated areas. Another restoration scheme was designed to adapt land management on arable land surrounding the protected wetland area in Berrington Pool. It resulted in 90 per cent of the water catchment having no inputs on their grassland, whereas ten years ago the entire catchment was under arable production with soil run-off and regular fertiliser application causing eutrophication and damage to the site. The change in the management of the wetlands is expected to lead to major improvements in water quality and the aquatic environment of the area.
A recovery of a large natural bog has been achieved in Forsinard Nature Reserve in Caithness, Scotland. The agri-environment support included payments for tree removal, drainage blocking and deer management. Water levels are recovering, and as a result several species of conservation concern such as skylark (Alauda arvensis) have returned to the area.

In **Finland** and **Sweden**, farmers were offered schemes for wetland creation, including support from the agri-environment (214), non-productive investments (216) and training and information measures (111 and 112). The schemes aim to improve both water quality and the management of water flows in river basins since Nordic farmers increasingly face dry summers and newly created wetlands can supply water for carefully managed irrigation. Multifunctional wetlands, the establishment and management of which is supported in Finland, can remove up to 1,000 kg of nitrogen per hectare depending on the design and location of wetlands. An agri-environment scheme which created nineteen wetlands in Uusimaa district in southern Finland demonstrated particularly beneficial impacts of a reduced nutrient load on biodiversity by creating a suitable habitat for dragonflies and water plants. The scheme involved also establishment of flood plains on arable areas that are susceptible to natural flooding and on terraced drainage areas, involving blocking up of grips. In Sweden, 5600 ha of wetlands were constructed or restored between 2000 and 2008, of which more than three quarters were financed through RDPs. Farmers may be refunded up to 90 per cent of the establishment costs for wetland development. The wetland schemes include also support for the creation of sediment ponds. An example of such agri-environment development is an artificial wetland in south-west of Sweden for the purpose of preventing nutrient run-off and protecting biodiversity. The wetland area of 18.85 hectares succeeded in creating suitable habitat for endangered bird species.

In **Denmark**, the implementation of agri-environment scheme for wetland creation, conservation or restoration may be complemented by state acquisition of land under the measure 'Conservation and upgrading of the rural heritage' (323). The objective of such schemes is to maintain water flows in river basins and improve aquatic environments (Dworak *et al*, 2009).

Source: adapted from Dworak *et al*, 2009; ENRD, 2010b; Natural England, 2009; Akkula *et al*, 2011; Natural England, 2011; RSPB Scotland, 2011; ENRD, 2012.

On agri-environment schemes aiming at improved water availability, there is less information regarding their outcomes compared to schemes addressing water quality. This may be partly due to the fact that many RDPs did not designate water availability as an objective to address directly or did not use agri-environment for this purpose (EPEC, 2004). Some ex-post evaluations demonstrate rather low interest from farmers in applying for schemes addressing water availability even in cases where there was a real need for the adoption of management more conscious of water use and where relevant schemes were offered. One of the reasons for a low uptake is the scope of change required in farming practices. For example, farmers in Umbria (Italy) were reluctant to sign in for schemes that required the conversion of arable to grassland but implemented schemes requiring reduced water use on existing crops (Oréade-Brèche, 2005). In Spain, a scheme involving both a change in crop type and reduced water use per hectare (verified by water meters) had limited uptake. Where adopted, the positive impact of the scheme on water availability was reduced by the continuing use of illegal boreholes. Evaluation indicated that an attitude by farmers who continued to view water as a private rather than a public good was a critical issue. It concluded that a more strategic approach, of which agri-environment would be a part, is needed for protecting water resources (Oréade-Brèche, 2005).

Several general issues in the effectiveness of agri-environment schemes are often caused by weak targeting. The European Court of Auditors highlighted over years that the link between the objective of the agri-environment scheme and the environmental pressure to which it responds has to be clearly classified as direct or indirect. However, such linkages were insufficiently determined in many schemes in 2007-2013 RDPs. In some cases the link was entirely absent, for example in some schemes targeting water quality. Issues relating to the geographic targeting of measures to particular areas with particular needs were also found. One such example is generalised application of agri-environment schemes on reducing livestock density and soil erosion was unconnected to the areas with specific needs in some countries. Good examples of geographic targeting include agri-environment schemes in Hungary for the protection zones of vulnerable water resources, flood areas and wetlands (European Court of Auditors, 2005; European Court of Auditors, 2011; other examples cited in Lillunen *et al*, 2011).

A number of ex ante evaluations for the 2007-2013 RDPs note that the effectiveness of agri-environment schemes could be in conflict with actions supporting the increase of competitiveness and productivity. For example evaluations perceived potential trade-offs between management actions focussed on water quality and investments into irrigation or tourism development (European Commission, 2008a). This issue is worth following in the next phase of this study, for example the forthcoming synthesis of mid-term evaluations is expected to provide some evidence.

Afforestation of agricultural land

Afforestation of agricultural land (221) receives about 6 per cent which is a relatively large proportion of the total RDP budget. It is supported in three quarters of RDPs. In a number of Member States, **non-productive investments** (216) are used alongside the afforestation support. The schemes may have a potentially high positive impact on water availability, water quality and management of water flows in river basins, alongside prevention of soil degradation processes such as soil erosion (Boatman *et al*, 2008). However, the evidence suggests that to realise these benefits in practice, the design (ie types of species, location of planting) and management of any afforestation is extremely important (Wildburger, 2004). Afforestation schemes have been subsidised by national governments from the 1990s, by CAP support through a voluntary afforestation measure since McSharry's reform in 1992 and through afforestation measure within rural development policy since the 2000-2006 programming period. Since no specific monitoring of these afforestation measures was required in the past, there is lack of data on their environmental outcomes. On the other hand, numerous issues have been identified in relation to the objectives, design and execution of the past schemes (EPEC, 2004; European Court of Auditors, 2005). Box 15 provides an overview of the potential benefits and adverse effects to water quality, water availability and management of water flows in river basins, including examples. As a result of issues arising in the past, in the 2007-2013 period RDPs had to include more stringent environmental objectives and safeguards for these schemes. Time will show whether these safeguards will yield net benefits for water in practice. In the Mediterranean areas, where all Member States have planned afforestation in their 2007-2013 RDPs (including Cyprus, Italy, Greece, Spain and Portugal), the bio-physical and climatic conditions make afforestation a particularly challenging activity and both the establishment and maintenance of afforested areas may involve irrigation (European Commission, 2009). So far there has been low uptake of the measure for the establishment of agro-forestry systems on agricultural land (222) which has a certain potential for fostering systems that help to improve water availability and maintain regular water flows in river basins. No data is available on the projects implemented so far.

Box 15: Examples of RDP afforestation schemes aimed at management of water flows

In Lower Saxony in Germany, afforestation support (221) and non-productive investments (216) are used to alter water run-off regimes and prevent floods. With this scheme, the region wishes to increase the capacity of water storage and retention, and enhance groundwater recharge. For this purpose afforestation of agricultural land (1,190 ha) and non-agricultural land (140 ha) is to be applied in areas in need of improved water retention. In Estonia, afforestation involving drainage was funded in the 2000-2006 period which caused concerns of environmental stakeholders. An afforestation scheme in 2007-2013 period in Extremadura (Spain) targets dehesas with a priority to areas with desertification issues and Natura 2000 sites. One of multiple objectives is to counter desertification and improve water retention in soils. Other objectives are prevention of forest fires and climate change mitigation.

The net environmental outcomes of this afforestation scheme for the traditional agro-forestry ecosystems remain to be seen.

In Cyprus, the afforestation scheme funded in the 2007-2013 period is targeted to abandoned areas. These areas suffer from soil erosion, desertification, and decreasing water quality and quantity. The afforestation scheme offers support to address these issues through a range of actions (creation and maintenance of woodland and development of simple irrigation system), including the protection of water quality.

Source: adapted from Fenton *et al*, 2008; Dworak *et al*, 2009.

5.2.2 Pillar 2 measures with an indirect focus on water

Capital investments at farm holdings

The **farm modernisation measure** (121) is used to deliver outcomes for water availability (in almost one third of RDPs) and water quality (in over one quarter of RDPs)[64]. Frequently investments aim to improve water management together with the delivery of other benefits for example for reducing greenhouse gas emissions and improving farm animal welfare, soil functionality and air quality. The capital investments through which these outcomes can be achieved involve livestock housing and manure storage, manure and silage handling and processing investments and activities to increase water use efficiency (ENRD, 2010b). The budget allocated to this measure is significant in most EU-12 Member States, accounting for over 13 per cent of their RDP budget. By comparison it accounts for about 8 per cent in the EU-15. Capital investments to **added value products** under another Pillar 2 measure (123) provide support to actions aimed at efficient water use and water savings in small and medium farms and processing enterprises.

Box 16 lists examples of capital investments for efficient water use and water savings through both measures. Annex 10 provides a detailed overview of types of capital investments supported through the farm modernisation measure, geographic usage in Member States, co-benefits to soil, biodiversity and other environmental objectives and potential conflicts.

The capital investments under the measure for the **infrastructure for development and adaptation of agriculture** (125) are used in the majority of RDPs, and in more than half of them they target water availability and water quality. They are is used in the Mediterranean regions in particular, but but also in several other regions which experience seasonal dry periods (Belgium-Flanders, Hungary, Romania, UK–England, and several French RDPs) for investments into the infrastructure for improving water availability, for example improved irrigation technology. Almost half of RDPs uses the measure to support more efficient, environmentally sustainable technology with a wide range of environmental benefits including water quality (ENRD, 2010b). The relevant actions are set out in Annex 10. The level of investment in water infrastructure under this measures is particularly high in island RDPs, for example France–Reunion and Portugal–Madeira (over 30 per cent of RDP budget) and in two others, Portugal and Italy-Trento (almost 20 per cent of the budget). In Portugal these investments aim to improve irrigation technology, and in Italy–Trento to support collective investments for the construction, upgrading, rehabilitation, modernisation of water storage and supply. Whether they deliver net water savings in practice remains to be seen from ex post evaluation.

[64] As noted, the evidence reflects the screening of RDPs prior to CAP Health Check in 2009 so the figures are likely to have changed.

Annex 10 provides a detailed overview of types of actions supported through the capital investments under the infrastructure measure, geographic usage in Member States as well as co-benefits to soil, biodiversity and other environmental objectives and potential conflicts. Box 16 below includes some of the examples of the use of these capital investments.

Box 16: Examples of capital investments for sustainable water use and management of water flows supported through the RDP farm modernisation, added value products and infrastructure measures

Sustainable water use

In France investments under the measure 'agricultural and forestry infrastructure' (125) were provided for integrated projects in irrigated areas. Support involves creating water storage facilities or modernising channels to irrigation fields in order to reduce over-exploitation of ground water in the region. In Malta actions promoting usage of recycled and harvested rain water, accompanied by mandatory training on relevant technologies, aim to deliver water savings. These actions receive support from the 'farm modernisation measure' (121). High water saving should be reached through investments in irrigation equipment, collection and storage of rainwater and restoration of dams for aquifer recharge. Most projects targeting water conservation techniques, such as rain water reservoirs. Over 180 RDP contracts had been signed with Maltese farmers involved in integrated approaches to modernising farm holdings by November 2009. In the UK funds for farm modernisation (121) support the construction of irrigation reservoirs to secure steady water supply. The implementation of the measure in East Anglia demonstrated that moving to winter abstractions helps in delivering water savings. Actions under the 'infrastructure measure' (125) in Romania focus on the modernisation and/or rehabilitation of irrigation systems and drainage systems. Through the improvement of infrastructure of agriculture and forestry, the scheme aims to decrease water loss by 10 per cent. However, investments are provided only for existing systems associated with Natura 2000 sites, so the benefits will be geographically limited. Modernisation of irrigation systems in Italy-Lombardia, (measure 125) and across Spain (measures 121 and 125) were proven successful in achieving water savings. The actions involved restrictions on irrigating farm parcels. The RDP in Aragon, Spain included actual water saving indicators, EIA and monitoring provisions in order to guarantee net water savings. Traditional open-air irrigation channels are being replaced by pipes and a centralised water reservoir has been constructed. Further instruments, such as training in new technology, implementing volumetric water pricing and reducing water allotments to irrigators could only improve the results of applied schemes, however these are not supported from the current schemes. In Cyprus, measure 121 co-financed the installation of a modern new 'smart' irrigation system for Solomou Nurseries which is both saving costs and conserving water. The nursery seeks to increase productivity with modern technology and at the same time facilitate environmentally sustainable technology. The new irrigation system includes automated desalinisation of underground water, collection of rain water and waste water collection and treatment.

Small and medium-sized enterprises in Malta receive support under the measure 'adding value to agricultural products' (123) by for reducing their dependence on natural resources. The actions involve improvements in technologies for conservation of water, improving efficiency of water use and re-use of water. In Slovakia small and medium-sized holdings receive support under the same measure (123) for the modernisation of technologies aimed at efficient water management, such as waste disposal and wastewater treatment facilities.

Management of water flows in river basins

As floods are becoming more frequent, issues related to water resources are targeted through several RDPs. In Poland RDP aims to improve flood protection of farmlands through the 'infrastructure measure' (125) and provides €440 million for these actions. This will enable reconstruction of the Lake Resko, Przymorskie levees and reconstruction of other levees in relevant areas. The capital investments are expected to help to protect farmland from further flooding; however net impacts remain to be seen.

The aim of non-productive investments (216) in Belgium – Flanders was to conserve water in upstream areas in order to enhance groundwater tables and ensure water supply in case of droughts. This programme of investments expected not only the delivery of positive environmental impacts by recharging deep groundwater but also positive agronomical outcomes, by helping reduce the damaging effects of drought. In addition the investments aim to enhance ordinary biodiversity of aquatic environments by installing buffer zones along water courses and to slow peak flood flows.

Source: adapted from Dworak *et al*, 2009, Boccaccio *et al*, 2009, ENRD, 2010b, ENRD, 2012, BIO Intelligence, 2012.

Capital investments under the infrastructure measure and non-productive investments have been combined in several Member States for actions involving maintenance of drainage, re-use of drainage water and other actions influencing the management of water flows in river basins. Annex 1 shows that over centuries drainage of wetlands changed some of Europe's most valuable habitats and replaced them by intensively managed croplands and grasslands, with an effect on multiple ecosystem services provided by wetlands, including carbon sequestration through peat soils (Russi *et al*, 2012). The loss accelerated in several countries since 1970s and drainage continues to negatively affect adjacent ecosystems. Large-scale drainage systems characteristic for many regions in Northern Europe negatively affect also water quality, as enhance the transfer of water-soluble compounds to watercourses (Skinner and Chambers, 1996; Van Oost *et al*, 2000). In addition, drainage profoundly affects water tables and water flows in the river basin. Whilst in some Member States agri-environment schemes pay for blocking drainage and restoring the wetland habitats (see above), others continue to provide capital investment grants for modernisation of drainage including a variety of actions, demonstrated in Box 17, including the establishment of new controlled drainage. A more comprehensive evaluation of environmental outcomes of these investments on the ground has not been carried out.

Box 17: Examples of capital investments for the re-use of drainage water and other actions aimed at management of water flows supported through the RDP infrastructure and non-productive investment measures

Re-use of drainage water and the modernisation of drainage

Over the period 2010-2013 farmers in Sweden and Finland can receive support for non-productive investments (216) for the maintenance and the establishment of controlled drainage. Through this system farmers are able to re-use the drainage water, close the drainage system and to retain the water within the field at certain times of year. Manipulating water levels aims to reduce the risk of water scarcity in dry periods. Since drainage exists on a large share of agricultural land, the maintenance of drainage infrastructure is likely to provide considerable benefits not only to the management of water flows but also to water quality through decreasing soil compaction and in effect reducing sediment run-off. However, it is arguable whether the provision of RDP support to draining more land for production would provide net environmental outcomes, and evidence for the outcomes achieved are unavailable. In Poland and Romania, capital investments under the 'infrastructure measure' (125) provide support for the modernisation of drainage, re-use of drainage water, re-profiling of water courses, etc. Although the RDPs proposed investments only to improve the existing drainage, commentators note that they may lack appropriate environmental safeguards to provide sufficient water protection.

Source: adapted from Boccaccio *et al*, 2009, Dworak *et al*, 2009, Herzon, I. pers. comm.

Capital investments in wider rural areas

Other types of capital investments addressing indirectly water objectives are provided under the Pillar 2 measures **Village renewal** (321) and **Basic services** (322). These measures are used in a group of RDPs to support investment into basic water management infrastructure in small municipalities. This includes establishment or modernisation of water supply, sewerage and waste water treatment plants. Such investments are supported in Poland, Czech Republic, Slovakia, Romania and Bulgaria, in several German Länder and in one French RDP.

Other land based Pillar 2 measures

Two land based Pillar 2 measures have potential to provide indirect water benefits. **Natura 2000 and Water Framework Directive payments** (213) could benefit water by compensating farmers for legal restrictions associated with the implementation of Natura and Water Framework Directive. However, Water Framework Directive payments were not introduced in RDPs due to the delayed implementation of river basin management measures. Payments for Natura 2000 farmers, applicable in areas designated for their biodiversity importance for management involving constraints on agricultural management, could have indirect effect to soil functionality and water quality. This is due to their role in a frequent combination of measures alongside agri-environment and Areas of Natural Constraints payments which are important for the continuation of extensive agricultural management in these areas, particularly where the economic viability of farming is under pressure. However, only a small proportion of Member States (26 RDPs) provided Natura 200 payments in 2007-2013. Less favoured areas payments (211 and 212) focus directly on rural vitality, agricultural landscapes and biodiversity. If additional requirements maintaining extensive grazing practices and maintaining extensive arable practices are put in place, benefits to water quality and soil can occur. The requirement for the maintenance of extensive grazing practices is used in over one third of RDPs. The requirement for the maintenance of extensive arable practices is used only in less than one quarter of programmes.

5.2.3 Pillar 2 cross-cutting measures

Training and advice

Training and advice has been supported under measures 111, 114 and 115. The types of actions supported by these measures include:

- Advice/training on developments in environmental technology
- Demonstration projects
- General environmental advice provision
- Training focused at more efficient nutrient management / input use

- Training on environmental management practices including organic management practices
- Training on sustainable resource use

Over ten per cent of RDPs provide focussed support to water quality, such as training on more efficient nutrient management. However, most programmes include much less targeted training and advice actions which could either encourage better management with regard to water quality (in more than three quarters of RDPs) or water availability (in around thirty per cent of RDPs).

LEADER

LEADER is a cross-cutting measure that enables the creation of local networks and action groups for the purpose of innovative and integrated development projects. It uses bottom-up strategies helpful for specific projects which address specific local problems. Some of the past projects involved the building of production capacities and short supply chains that may help extensive grazing farms stay in business, stimulate demand for organic products, sustainable tourism strategies involving improved environmental management in rivers, with benefits to aquatic environments, and promoting sustainable management of Natura 2000 sites. 2007-2013 RDPs typically benefits of proposed LEADER actions for the environment including water (European Commission, 2008b) but it is not always clear how these outcomes will be achieved and evidence is lacking for the actual water effects of past LEADER actions. Box 18 provides an overview of examples. Experience with the LEADER approach has been also influential in some new Member States in creating farmers' networks in structurally lagging and remote areas with extensive grazing systems. However, issues remain with the assessments of the projects with regard to their actual effects. Overall, it was noted that there is a history of LEADER actions supporting more productive sectors than aiming to improve resource management (European Court of Auditors, 2010). Box 18 below provides an overview of relevant examples implemented in RDPs from the year 2000.

Box 18: Examples of participatory approaches affecting water quality and water availability supported through LEADER

In Spain-Andalusia, Local Action Groups organised and applied funds for enhancing water quality and quantity. The schemes focussed on modernisation of infrastructure related to the management and the sustainable use of water resources, particularly for farms using traditional gravity irrigation practices. The schemes were organized and funded under Leader.

Leader programme in Finland supports not only farmers but also associations seeking to create wetlands when farmers are unable to do so. Evidence for the environmental outcomes of the projects is missing.

A two year Leader project in the UK aimed to create a balance between maintaining the exceptional natural environment and achieving sustainable economic growth in agricultural sector provided specialised courses designed in response to local farming needs, practical skill programmes, support packages such as on-going mentoring and coaching and environmentally sustainable practices for training and advice. This new advisory and training service has supported farmers to develop sustainable farming practices, increase their incomes through diversification, processing, environmental management and local marketing. Although there is a potential to improve on farm management by the project, it is unclear whether it war materialised in actual improvements.

A Leader programme in Friesland and Lauwersland, Netherlands, applied innovative actions with benefits for water, soil and energy. The actions involved the processing of wastewater on dairy farms by using special filter, modernisation of trickle irrigation in seed potato production, composting manure and vegetable waste and planning energy management in dairy farms.

A Leader project in France, aimed at protecting environment, nature and natural heritage, applied a participatory approach to water management. The project targeted young people and children through trainings, awareness raising activities and educational work projects that focussed on sustainable water management in rural areas.

In Poland, the Local Action Groups in the Nakło region developed over a decade various projects to engage with the Noteć river as part of the environmental, social and economic heritage of their area. Actions sought support from a variety of funds, including national funding, European Fisheries Fund, Structural Funds and Rural Development funds. Some of the declared aims of the project were to improve the condition of the natural river environment, restore and develop tourist and leisure opportunities in the Noteć Valley and control water degradation. It is unclear to what extent the project helped to achieve a better status of waters in the area and to ensure transparent use of the mix of support.

Source: European Commission, 2003, Vigneau, 2007, European Commission, 2008c, Dworak *et al*, 2009, ENRD, 2012b.

5.3 CAP Pillar 1 measures

There are a number of Pillar 1 measures that have the potential to contribute towards water objectives. These include cross compliance, presented in Section 6.3.1, and direct support through Article 68 which enables support to specific types of farming or activities that are important for the protection of the environment, presented in Section 6.3.2. The latter measure is proposed to be discontinued after 2014[65].

5.3.1 Cross compliance

Cross compliance sets out a minimum level of environmental management and plant and animal health that is a condition of receipt of direct payments. Farmers that are in breach of rules are penalised by the reduction or removal of their direct payment. The requirements for farmers include the Statutory Management Requirements (SMRs) and the maintenance of agricultural land in Good agricultural and Environmental Condition (GAEC). An additional quantitative obligation for Member States requires the maintenance of a ratio of permanent pasture at a stable level. SMRs include all relevant obligations from existing legislation that apply at the farm level, including the Groundwater Directive[66], Nitrates Directive and Sewage Sludge Directive[67].

[65] According to the Proposal for a Regulation of the European Parliament and of the Council establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy, COM(2011) 625/3, is under negotiation with the European Parliament and the Council.

[66] Council Directive 80/68/EEC of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances, OJ L 20, 26.1.1980, p43.

[67] Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture, OJ L 181, 4.7.1986, p6.

Within the pre-2014 GAEC framework there are eight compulsory standards and seven optional standards. Member States have designed GAEC standards in ways that reflect their different agronomic, environmental and climatic conditions which means that the baseline can vary across the EU and in some situations between regions. Compulsory standards are focused directly on the provision of water benefits through obligations to establish buffer strips along water courses and the control of the existing authorisation of water use for irrigation. These standards are relatively recent. The implementation started in 2010 for the GAEC on water authorisation and in 2012 for the GAEC on buffer strips.

Several other compulsory and optional standards focus directly on soil or biodiversity and may have potentially important impacts on water quality or water availability (for synergies see Section 5.2). These standards include:

- Minimum soil cover;
- Standards for crop rotations;
- Maintenance of landscape features; and
- Retention of terraces.

So far there have been no requirements in cross compliance to monitor and evaluate the effects of any GAEC measures. If monitoring is extended to Pillar 1 as it is proposed for the post 2014 period[68], time may show the net benefit of such GAEC measures in the future. The most recent pan-European evaluation of the impacts of cross compliance was published in 2007 and is now outdated (Alliance Environnement, 2007). Since then, changes in the implementation of cross compliance included for example the introduction of GAECs on authorised water use and buffer strips resulting from the 2009 CAP Health Check.

Evidence demonstrates that cross compliance in the EU as a whole, and GAECs in particular, looks demanding in relation to the environment on paper, but the degree to which the standards are implemented and enforced in practice is extremely variable and as a result the standards may be relatively ineffective (Alliance Environnement, 2007). The reporting performance of many Member States relating to non-compliance is poor and the comparability of data between Member States is problematic (European Court of Auditors, 2008; BirdLife, 2009). Box 19 provides examples of information on non-compliance with the Nitrate SMRs and the impact of GAEC standards on certain soil and water issues.

Anecdotal evidence suggest that the GAEC standards implemented in Member States for soil erosion often have weak requirements for permanent vegetation cover and do not adequately prevent the exposure of soils to climatic influences (Diaz-Chavez *et al*, 2012). The existing GAEC on burning arable stubble is too narrow to enforce basic actions for protecting levels of soil organic matter (but this is proposed to change after 2014). In situations where markets forces are driving increased production in arable areas, including production for bioenergy markets, the GAEC standards often are not demanding enough to ensure that the resources of soils and water are maintained above sustainable thresholds (Diaz-Chavez *et al*, 2012). Changes proposed in the GAEC framework in relation to soils after 2014 are discussed below.

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[68] Proposal for a Regulation of the European Parliament and of the Council on the financing, management and monitoring of the common agricultural policy, COM(2011) 628/3, 2011/0288(COD), is under negotiation with the European Parliament and the Council

Box 19: Effectiveness of cross compliance

Notified breaches

One indicative source of effectiveness of cross-compliance is the number of notified breaches. For example, recent data from Scotland demonstrate that overall the number of breaches notified has declined since 2008, whilst there has been an increase in the number of breaches notified for non-compliance with the statutory management requirement for the Nitrates Directive (from five in 2010 to seventeen in 2011) (Scottish government data quoted in IEEP, forthcoming). This means that the share of breaches for non-compliance with the Nitrates Directive within all breaches increased steeply. For comparison, data from Sweden show that the greatest levels of non-compliance between 2005 and 2009 have been notified also in relation to the Nitrates Directive (Jordbruksverket, 2011), accounting for circa 10 per cent of all breaches over the period. This would suggest that there may be a greater issue with adherence to the Nitrates Directive than previous monitoring figures would suggest. It is also important to note that the EU-wide one per cent inspection requirement means that breaches notified are only indicative of the issues in compliance which possibly affect the remaining 99 per cent of farmland. The scale of issues in non-compliance may be thus much larger than inspection figures indicate.

Impact of GAEC standards for specific soil and water issues

Relating to GAEC standards in particular, several sectoral studies recently concluded that standards applied are too weak to counter specific pressures to soil and water (eg pressures from the expansion of biofuel crops according to Diaz-Chavez *et al*, 2013; and from the continuous maize systems leading to the build-up of pests in soils, according to FCEC, 2009). By definition the GAEC framework aims to enforce basic good practice and it is not meant to fully regulate the land use and its environmental impacts.

In the revised CAP cross compliance requirements are proposed to be streamlined[6]. The number of SMRs has been proposed to be reduced to 13 (from 18) and the number of GAEC standards to 8 (from 15) but the content remains to a large extent the same[69]. Relating to the water resource, the Sustainable Use of Pesticides Directives is proposed to be incorporated as SMR, whilst the introduction of the Water Framework Directive as SMR has been removed from the proposal in the European Parliament's plenary vote. Within the GAEC framework, some existing standards have been superseded by the 'green' direct payment measures. Two new GAEC standards have been proposed, both relevant to the protection of water and soil resource, one focussing on soil organic matter and the other on the protection of wetlands and carbon rich soils. Against the backdrop of the evidence provided in this report, it is unfortunate that the latter GAEC has faced such resistance from both the European Parliament and Member States in Agriculture Council[70].

[69] The Groundwater Directive SMR is proposed to be moved to become a standard of Good Agricultural and Environmental Condition (GAEC) and the Sewage Sludge Directive removed from the list, according to the proposed financing and monitoring Regulation COM(2011) 628/3, ibid.

[70] Both the European Parliament and the Agriculture Council negotiating mandates propose that the GAEC on the protection of wetlands and carbon rich soils should be removed from the new cross compliance framework.

5.3.2 Article 68 measure

Important benefits for water in the 2007-2013 programming period (and before) may have been provided through Article 68 funding. The funding is expected to be discontinued in post-2014 CAP[71]. Member States are permitted to use up to ten per cent of their total direct payments envelope, to encourage specific types of farming which are important for the environment, quality production and marketing and/or to buffer the consequences of decoupling of support in particularly sensitive sectors. Ten Member States employ the actions for special support to farming which is important for the protection of the environment (Article 68 (1)(a)(i)) and for agri-environment benefits (Article 68 (1)(a)(v)) for schemes that have the potential to provide benefits to water[72]. These include a range of actions such as, organic farming, maintenance of permanent pasture, crop rotations, extensive grazing and support to legumes and fodder crops.

5.4 Other CAP measures

Organic farming

The European Organic Action Plan, published in 2004, built up on an EU-wide definition of organic farming existing since 1990s and proposed to improve the design and implementation of EU organic farming standards[73]. The Council Regulation (EC) No 834/2007 and its implementing rules thoroughly improved the existing legislative framework, specified the objectives and principles, and set out production standards and control and labelling requirements[74]. A review process is underway at present, aiming to thoroughly revise the legislative framework. Funding for the establishment and maintenance of organic farming systems has so far come from Pillar 2. In the 2007-2013 programming period, organic farming was included in the agri-environment measure (214) and all Member States use this support. The schemes focussing on the introduction of organic farming aim to provide improved water quality (alongside other objectives) in about half of RDPs and the schemes focussed at the maintenance of organic farming have this goal in almost two thirds of RDPs. Water availability is a much less frequent goal stated in these schemes. Schemes focussing on the introduction or the maintenance of organic farming included this objective in only about 15 per cent of RDPs (ENRD, 2010b). In the post-2014 CAP, it is proposed that organic farming is a self-standing measure within Pillar 2 and receives direct green payment within Pillar 1[75]. Section 5.6 provides an overview of the basic principles for the effective use of these funds in post-2014 period.

Good evidence exists on benefits of organic farming to water quality and soil functionality. These can be attributed to the ban on the application of artificial fertilisers or pesticides. Organic farming also relies on management actions that are frequently replaced by intensive management in conventional agriculture (eg crop rotation, application of animal manure, minimum tillage, mechanical weed control, hedge management etc). Use of animal waste and green manures can replace nitrogen and thus reduce nitrate leaching and build up soil organic matter content.

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[71] The proposed Regulation on direct payments COM(2011) 625/3, under negotiation with the European Parliament and the Council.

[72] Denmark, Finland, France, Ireland, Italy, the Netherlands, Poland, Portugal, Spain, Romania, and the UK-Scotland.

[73] Communication from the Commission to the Council and the European Parliament: European Action Plan for Organic Food and Farming. COM(2004)415 final.

[74] Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products; Commission Implementing Regulation (EC) 889/2008 and Regulation (EC) 1235/2008.

[75] According to the proposed Regulation for direct payments COM(2011) 625/3 the proposed EAFRD Regulation COM(2011) 627/3, both under negotiation with the European Parliament and the Council.

Crop rotations with legumes may be particularly effective for providing water and soil benefits (for details see Section 5.2). According to the survey by the European Court of Auditors, the positive outcomes of organic farming agri-environment schemes for water were documented in all Member States under survey. 30 studies in 2005 provided evidence that organic farming practices were effective in achieving their environmental benefits, such as reduced water and air pollution through decrease in the use of inputs (European Court of Auditors, 2011). Improved water quality beneficially affects the status of wider habitats. For example, organic arable systems in south-west of England showed higher plant abundance and species richness than their conventional counterparts (Hole *et al*, 2005; Norton *et al*, 2009; Gibson *et al*, 2007).

Box 20: Changing benefits of organic farming in diverse conditions and impact on yield

Benefits of organic farming on water and biodiversity are more likely to occur in heterogeneous landscapes, with relatively large amounts of semi-natural vegetation than in simpler landscapes dominated by intensive farming. Also, organic farming mostly succeeds in providing water benefits on smaller farms with silt/clay soils. Although shallow and well drained soils are easy to manage, they do not contain enough nutrient levels and are prone to higher leaching (Gabriel *et al*, 2009). In addition, organic management performs better on weak-acidic to weak-alkaline soils (ie soils with a pH between 5.5. and 8.0) and less well on strongly alkaline and acidic conditions, where phosphorous is less available to plants and crops depend to a larger extent to agro-chemical inputs (Seufert *et al*, 2012).

Two recent meta-reviews examined the relationship between yields of organic and conventional agriculture. A meta-review by Seufert *et al*, 2012, includes 66 studies from EU and non-EU countries, reporting 316 comparisons on 34 different crop species, addressing only studies on certified organic systems which compare organic and conventional farming on the same temporal and spatial scale. It concludes that some generic differences in yields between organic and conventional agriculture do exist, the performance of organic systems varies substantially across different farming systems and environmental and climatic situations. On average, overall organic yields are 25 per cent lower than conventional yields. The performance of organic farming systems varies across the type (eg fruits or vegetables) and species of crop (eg maize or barley). For example yields of organic fruits and oilseed crops are less than those for the same crop types grown conventionally but not to a significant degree (3 and 11 per cent less). In comparison, organic cereals and vegetables have significantly lower yields than their conventional counterparts (26 and 33 per cent less). However, soils in organic systems have better water holding capacity and infiltration rates, therefore organic agriculture have higher yields than conventional systems under drought conditions and excessive rainfalls. Organic yields are lower in irrigated conditions (by 35 per cent compared to conventional systems) than in rain fed conditions (by 17 per cent). However, most studies under this review compare organic systems to commercial high-input systems which have predominantly above average yields. No study comparing organic to conventional subsistence farms was identified that could be included in the meta-analysis. Therefore, the claim that organic agriculture can increase yields in smallholder agriculture in regions with extensive systems cannot be either ruled out or convincingly supported (Seufert *et al*, 2012).

A meta-review by Tuomisto *et al*, 2012, includes 71 studies that address EU agriculture, compare organic and conventional farming and provide quantitative results on at least one of the range of environmental impacts. It concludes that organic farming practices generally have positive impacts on the environment per unit of area, for example higher soil organic matter content and lower nutrient losses (nitrogen leaching, nitrous oxide emissions and ammonia emissions). However, they generally have higher impacts per product unit. For example energy requirements are lower per product unit but land use and eutrophication potential are higher per product unit. As in the study by Seufert *et al*, the results varied considerably across different farming systems. The key challenges to environmental resources therefore differ in conventional farming and organic farming. Conventional systems should according to Tuomisto *et al*, 2012, improve recycling of nutrients, soil functionality by more diverse crop rotations and incorporating organic matter, and enhance biodiversity. For organic systems the study recommends improved nutrient management and increase in yields (Tuomisto *et al*, 2012).

Farm Advisory System

Setting up a Farm Advisory System (FAS) is a legal obligation for Member States[76]. Funding for the FAS comes from Pillar 2. Advisories must provide information on the statutory management requirements (SMR) and the standards of good agricultural and environmental conditions (GAEC) as a compulsory element of the service. Often it also supports farmers in respect to minimum requirements on fertilisers and plant protection products. However it is voluntary for farmers to seek advice. A recent pan-European evaluation found that 35 per cent of farmers perceived that advice through FAS was useful in improving their awareness concerning effects of farming practices on water. Water/soil issues included in cross compliance are seen as more important by farmers than the water/soil issues that are not part of cross-compliance and other issues such as biodiversity. 12 Member States also include information on the implementation of agri-environment schemes or water protection schemes as voluntary information available to farmers through FAS (such as information on the standard on protection of permanent pasture, the crop rotation standard and catch crops, the minimum soil cover standard, standards on the maintenance of soil organic matter, requirements under the Nitrates Directive concerning the application and storage of manure, etc (ADE *et al*, 2009a)). Box 21 below provides an overview of good practices relating to water under the FAS.

Box 21: Examples of good advisory practices relating to water

In Belgium, some of the requirements on the use of plant protection products, such as requirements on safe storage, the checking of the application of machinery and rules on pesticide use close to water and other sensitive sites, are included in national good agricultural practices. 12 Member States include advice on agri-environmental issues in Farm Advisory System (FAS) and all of them provide Pillar 2 support for the use of farm advisory services. Advice includes elements related to Natura 2000 (Czech Republic), water protection schemes (Estonia), agri-environmental protection plans (Hungary) and agri-environmental requirements (Lithuania). In Lithuania FAS consists of three main advisory services, with one specifically focussing on agri-environmental issues. This service system provides guidance for farmers who intend to participate in agri-environmental measures. In the UK FAS provides advice to farmers and land managers on how to reduce diffuse water pollution from agriculture. Such advice is delivered by Catchment Sensitive Farming Officers who inform farmers on measures with a potential to improve land management relating for example to soil

[76] Obligations under Articles 12 and 13 of Council Regulation (EC) No 73/2009 of 19 January 2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers.

with likely indirect effects for water quality. The Flemish Land Agency (FLA) is a governmental agency working on reduction of water pollution by nutrient losses from agriculture. It provides advice service, additional to the FAS subsidised by the Department of Agriculture, and guides farmers in reducing nutrient losses to the environment.

Source: ADE *et al*, 2009a; ADE *et al*, 2009b; European Commission, 2010b; Berglund and Dworak, 2010

5.5 Other EU and national funding measures

Other EU funding measures

The EU funding instrument for the environment, LIFE+, can be used to co-finance pilot projects that aim to improve water availability, water quality and management of water flows. The types of activities that are supported by LIFE+ funding range from land management practices, awareness raising to support for the installation of new technologies (see Box 22 for examples). EU Cohesion Funds, Structural Funds (ERDF) provide another type of funding that may support capital investments targeting water infrastructure.

Box 22: Examples of LIFE+ projects targeting better water quality

Pig production in the Spanish region of Aragón accounts for a considerable water and air pollution due to generation of 13.5 million m^3 slurry per year. Therefore LIFE ES-WAMAR project introduced an integrated management model for the processing and distribution of pig slurry (eg via pipelines, lorries) in order to enhance water quality by minimising nitrate contamination and maximizing nutrient recycling. The model adapted to local circumstances brought evident environmental benefits; it reduced nitrogen overload of the soil and replaced chemical fertilisers with natural ones (European Commission, n.d.).

The main objective of Artwet project in France, Italy and Germany was to reduce the effects of agricultural pesticides on water pollution. By using vegetated ditches, natural and constructed wetlands and forest plots the project partners managed to treat and in some cases remove pesticides before they entered the aquatic system (European Commission, n.d.).

NITRABAR LIFE project in Northern Ireland succeeded in installing a cost-effective biological pollution control technology, which reduced nitrate concentrations by over 90 per cent. This innovative technology transforms nitrate from groundwater into harmless nitrogen gas and hence provides environmentally beneficial solution to diminishing nutrient enrichment in rivers and lakes and enhancing water quality. Additional advantages are the use or organic materials and absence of need for energy input once the technology is installed (European Commission, n.d.).

The overall aim of AWARE project in France was to reduce the amount of pesticides in water by monitoring the amount and type of chemicals used through sprayers. Initially the project targeted wine growers but aimed to extend wider. The monitoring device was able to reduce pesticide use by 50 per cent at the early vegetation stage and 30 per cent with grown vegetation, resulting in reducing pesticide lost in the ground by 30 per cent (European Commission, nd). Another LIFE project in France was developed to reduce nitrate contamination in order to improve water quality in Peron river basin. This was to be done by identifying sources of water contamination and promoting good agricultural practices, tools and technology to face them. The project succeeded in involving 76 farmers signing 41 different contracts, through which they committed themselves to water protection measures. The project indeed reduced nitrate levels by 20 to 30 per cent, particularly on rape (by 40 units) and wheat fields (10 units) and reduced the risk of pollution linked to phytosanitary by 90 per cent (LAON Chamber of Agriculture, 2007).

Financial instruments to potentially accompany the CAP funding

Elements of RDPs may be supported by the use of financial instruments[77]. These can comprise venture capital funds, guarantee funds and loan funds which operate at national and regional level and are approved as part of the individual RDP. In the 2007-2013 period, six Member States have set up financial instruments to support the use of Pillar 2 funds for rural development actions (Bulgaria, Romania, Latvia, Lithuania, Italy (not all regions) and Greece). None of the financial instruments used specifically focus on water, soils or climate change, but it is possible that some investments may have funded actions related to these objectives. However, there is insufficient evidence available about such impacts.

Payments for ecosystem services, market based measures and voluntary initiatives

Payment for ecosystem services (PES) is a type of measure that through which the beneficiaries of ecosystem services pay the provider of those services. According to The Economics of Ecosystems and Biodiversity in National and International Policy Making (TEEB), it may comprise public or private payments for sustainable management of water resources, agricultural soils, biodiversity conservation or carbon sequestration (ten Brink *et al*, 2011). Such PES schemes could be designed at the local or regional catchment level, and target synergistic benefits for land management that improves soil and water protection. PES could thus incentivise land users to adopt recommended practices on the priority soils in identified risk zones (FAO, 2007). The use of CAP funds for agri-environment-climate soil management is a type of publicly funded PES scheme. PES schemes promoted by private businesses are useful in particular where the scheme results in relatively low additional soil benefits compared to the baseline, but can compensate the upfront cost of the change of agricultural practice otherwise resisted by farmers. Such private schemes can also incentivise landscape scale uptake. The PES payment rates should be based on local land-use opportunity costs, the area of the property committed to the project and the quality of the environmental services provided (Cassola, 2010). Box 23 below and Section 3 provide examples of successful PES schemes funded by private businesses.

Market base mechanisms and voluntary initiatives could also recognise the value of soil carbon stored or GHG emissions saved through conservation land management. An example is also provided in Box 23.

Box 23: Examples of PES schemes, market based mechanism and voluntary initiatives targeting better water management

Privately funded PES: In the early 1980s it was recognised that the intensification of agriculture in **the Vittel catchment** posed a risk to the nitrates and pesticide levels in the mineral water. To address this issue Vittel decided to provide incentives to farmers to voluntarily change their management practices to reduce contamination. They initiated an incentive package which included payments of €200 /ha/year over 18 or 30 year contracts; up

[77] Article 50 of the Implementing Regulations 1974/2006.

to €150,000 per farm to cover the cost of all new equipment and building modernisation; free labour to apply compost in farmers' fields; and free technical assistance including annual individual farm plans and introduction to new social and professional networks. All 26 farms in the area adopted the contract. Payments are not conditional on changes in the nitrate levels in the aquifer but are based on new farm investment and the cost of adopting new farming practices. Both nitrate rates and farm management are regularly monitored and recommendations for manure application are adjusted if necessary (Rollett *et al*, 2008). One of the main factors of the success of the scheme has been the trust built up between the farmers and the company as a result of, amongst other factors, a long-term participatory process (Cooper *et al*, 2009; Perrot-Maître, 2006).

The **Belarus restoring peatlands** project is an example where rewetting and sustainable management of peat soils is envisaged to be financed by the commercial sale of credits from avoided carbon emission and restored carbon sequestration. The quantification of GHG emission reductions shall facilitate the certification and sale of carbon credits on the voluntary market.

The Campaign for Farmed Environment, UK is a voluntary approach led by farmers. One of the three themes is focused on water and soil. Farmers subscribing to this campaign theme are required to establish or maintain a buffer strip with a minimum width of 6m (including the 1m protection zones under cross compliance) alongside a watercourse. No cultivation and no fertilisers, organic manures or waste are allowed.

Certification schemes

EU guidelines for best practice for voluntary certification schemes offer a broad framework for certification schemes (European Commission, 2010). According to these guidelines, certification schemes can apply to any stage of the food supply chain and participants can be subject to a range of requirements. Production standards and environmental land management are among many other areas potentially affected by certification requirements. Schemes can generally apply both to end products and production processes. However, those schemes that might deliver environmental benefits for water quality and quantity tend to apply to management systems. Certification schemes that apply to management systems should clearly identify whether the required actions correspond to the 'baseline' (ie cross-compliance) or provide environmental impacts 'above baseline' (European Commission, 2010). A 2010 inventory of certification schemes across the EU recorded 441 schemes, of which 54 were identified as supporting the sustainable use of natural resources and just one as supporting climate change (Areté, 2010).

Box 24: Examples of certification schemes with potential water benefits

The certification scheme identified as delivering **benefits for climate change** has been adopted in **Sweden**. It is of particular relevance to water management, since the criteria require participants to limit nitrogen inputs so as to reduce nitrous oxide emissions (Richert and Carlbourg, 2012). This has a knock-on effect for water quality in the catchment area as producers are required to reduce nitrogen fertiliser inputs thus reducing the risk of nitrate leaching. Of the 54 certification schemes that support the sustainable use of natural resources, an interesting example to water management is the **LEAF marque,** operating in the UK. In particular, the LEAF marque has recently launched a new set of guidelines for their participants which develops on the adoption of integrated farm management to specifically target water management. The guidelines, Simply Sustainable Water, offers six simple steps for LEAF farmers to manage their water quality and water use on farm (LEAF *et al*, 2013). These guidelines require farmers to keep records of the amount of water used and prioritise where water use is most needed to highlight where savings might be made. This does not just refer to irrigated crops but livestock farming systems too. The guidelines also highlight the importance of land management actions such as soil management for protecting water resources, identifying crop variety selection and cultivation practices that will minimise the impact of farming on the soil's capacity to protect the water (LEAF *et al*, 2013).

5.6 Principles for the effective use of the CAP funds

Previous sections identified a number of technologies, tools, good policy practices, improvements in infrastructure and land management actions that are useful in water and soil conservation efforts. Funding for a majority of these actions was already available under the 2007-2013 CAP. The post-2014 CAP will have three objectives, viable food production, sustainable management of natural resources, and balanced development of rural areas, so water sustainability is addressed by one of these objectives. In assessing whether there are additional actions to improve sustainable water use that merit public support, one has to bear in mind the principles for effective funding. Due to an expected change in the architecture of the CAP, the application of these principles is likely to change too. Although a detailed analysis of the proposals for post-2014 CAP is not a focus of the study, the key changes need to be taken into account in proposing relevant policy options for this study. This section summarises the basic funding principles for effective use of Pillar 2 support; outlines the key stages of the policy cycle for the integration of water and soil objectives; and summarises the relevant changes proposed in post-2014 CAP.

Changed architecture of post-2014 CAP

With the changes proposed for the post-2014 CAP, the architecture of funding of Pillar 1 changes significantly and this has important consequences for assessing the effectiveness of the use of the CAP funds for water objectives. The Commission's proposals involve a notable shift in the focus of Pillar 1 which would require Member States to introduce a green payment for practices beneficial to climate change and the environment (30 per cent of the national ceiling), alongside a Basic Payment Scheme and a payment for young farmers. In addition Member States would have the option to introduce a payment to farms in areas facing 'natural constraints', and coupled payments for specific support to types of farming or sectors undergoing difficulties (a successor to Article 68)[78]. As a result, three layers of land based measures affecting environment to varying degrees could be delivered by the revised CAP. These and other basic types of support available after 2014 are illustrated in Box 25.

[78] According to the proposed Direct Payment Regulation COM(2011) 625/3, under negotiation with the European Parliament and the Council.

Box 25: Structure of the revised CAP in relation to environmental delivery

The draft legislative proposals for post-2014 CAP comprise a series of regulations including: Pillar 1 direct payments[79]; Common Market Organisations; Pillar 2 funding[80]; Cross compliance, financing and monitoring; and on transitional arrangements[81]. A Common Strategic Framework 2014 to 2020 will set out thematic objectives for the Pillar 2 support as well as other EU funds[82].

The revised CAP includes three layers of land based actions affecting the environment:

- Actions to comply with cross compliance requirements;
- Actions to comply with requirements for green direct payments under Pillar 1; and
- Agri-environment-climate actions (AECM) under Pillar 2 that provide benefits additional to a new environmental baseline which is proposed to include the revised cross compliance requirements, the greening measures, and requirements on the use of fertilisers and plant protection products defined by Member States.

As a result, land based water and soil actions would in principle be allowed to receive[83]:

- No funding beyond receipt of the Pillar 1 Basic Payment if the actions are required under cross compliance
- Green direct payments if the water or soil actions are part of the suite of compulsory P1 greening measures
- Additional financial support to compensate for income foregone and additional costs incurred through undertaking actions under the AECM payment that go beyond those carried out under the Pillar 1 greening measures and cross compliance.

There are several other types of Pillar 2 measures that potentially could be used to deliver water and soil benefits. These may receive support through:

- Other land based payments (WFD payments; Areas of Natural Constraints payments)
- Capital investments in infrastructure (including non productive investments);
- Payments to support the development and marketing of added value products;
- Measures to encourage Information provision, advice, innovation, research, and cooperation; and
- Measures to help farmers manage and cope with risks, for example in relation to natural disasters.

Source: Silcock *et al*, 2012

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[79] Ibid.

[80] The proposed EAFRD Regulation COM(2011) 627/3, ibid.

[81] The proposed regulation COM(2011) 628/3, ibid

[82] The proposed Common provisions regulation COM(2011) 615, ibid.

[83] According to the CAP legislative proposals, ibid, under negotiation with the European Parliament and the Council.

In principle, to achieve good value for money, all water and soil actions in receipt of support should deliver additional environmental benefits than those which would have been achieved without the funding. Relating to potential support to water and soil actions, the extent to which these benefits 'would have happened anyway' matters as the so called counterfactual scenario. Only the environmental benefits over 'what would have happened anyway' merit public support. Another fundamental principle underpinning the rules for public expenditure in the EU is that no costs for the same activity be funded twice from the EU budget.

Box **26** provides examples for both principles.

Box 26: Key principles to guide the CAP support for the provision of additional environmental benefits to waters (and soils)

Principle 1: Achieving additional benefits
Example of water/soil benefits that merit CAP support: Grassland management on a livestock farm in a semi-natural habitat safeguards regular water flows in the river basin, maintain soils and biodiversity, and the farm operates at financial loss. If the farm increased productivity and intensified grassland management, introduced regular seeding and occasional ploughing of grass, in order to maintain the livestock system based on silage, it will involve significant decline in water protection, soil organic carbon and biodiversity. Thus, the incentive to continue maintaining semi-natural grassland habitat through AECM support is justified.

Example of water benefits that do not merit CAP support: Modernisation of water piping in farm buildings should bring economic benefits in the medium and long term and slightly improve efficiency of water use. Farmers are likely to make the capital investment in anticipation of economic benefits, without Pillar 2 funding. Thus the water benefits achieved through the use of funding are incidental and do not merit public support *per se*. The European Court of Auditors recently applied this principle in highlighting irregularities in the use of Structural funds to support capital investments into improved energy efficiency in modernisation projects for public buildings (European Court of Auditors, 2012). The investments were primarily motivated by savings to local budgets, although the capital investment grants were justified by environmental benefits through the reduced use of energy. However, there are situations where the cost of the capital investment for manure storage or installation of water meters is beyond the financial capabilities of the farmer. In well considered situations, public support may be justified to make such investments in new infrastructure. In sum, the use of public funds for reduced water use in public buildings in rural areas and farm holdings, eg through improved irrigation, may be justified only if the water savings achieved comply with stringent eligibility criteria.

Principle 2: No double funding
It is a principle underpinning the use of public expenditure in the EU Financial regulations that no costs for the same activity be funded twice from the EU budget. This issues has been the subject of much debate during recent discussions on the CAP proposals in relation to the interface between the green direct payments and payments under land management schemes in Pillar 2, such as via the agri-environment-climate measure. Explicit rules will be needed to ensure that double funding is avoided (Hart, 2012).

Principles 3: Funding incentives linked to established environmental needs and based on empirical evidence
Empirical evidence has to inform the calculation of impacts proposed for funding through the CAP measures. Evidence should be based on tangible observations established through surveys, causal relationship or case studies, or, when the effect cannot be empirically observed, on a comparison with an environmental situation which would have resulted if no funding intervention took place (ENRD, 2012c). The targeted impacts of public interventions to water and soil must be linked to clearly established environmental needs in specific areas (European Court of Auditors, 2011; ENRD, 2012c).

Pillar 2 funding after 2014

Funding from the Pillar 2 to water (and soil) actions has been available to farmers, land managers, and municipalities in the 2007-2013 period through the types of measures set out in previous sections. In the revised CAP, the list of measures Pillar 2 changes in form rather than content, compared to the previous programming period[84]. Water objectives are embedded in two of the six new rural development objectives of Pillar 2 measures proposed for the 2014-2020 period, ie restoring, preserving and enhancing ecosystems and promoting resource efficiency and transition to a low carbon economy[85], with the environment and climate being cross-cutting issues. To meet these objectives, different combinations of the above measures can be used. The Commission's proposals provide a guide to Member States, suggesting that that 25 per cent of each RDP budget should be allocated to environmental land management and climate objectives, including water through the use of three measures: the agri-environment-climate, organic and Areas of Natural Constraints measures.

Support to actions with potential water benefits under the revised CAP Pillar 2 will be available within the context of a decline in the overall rural development budget, approved under the Multiannual Financial Framework 2014-202086. The overall budget available in 2014-2020 is set to be €84.9 billion; a significant decrease compared to the 2007-2013 period The MFF agreement states that Member States can transfer up to 15 per cent of funds from Pillar 1 to Pillar 2, which could fund environmental and climate actions in Pillar 2[87]. However, in a new development, all Member States would also have the possibility to transfer up to 15 per cent (for some countries 25 per cent) of their

[84] According to the proposed EAFRD Regulation COM (2011) 627/3), under negotiation with the European Parliament and the Council. They are likely to include incentive payments to land based actions - Article 29 (Agri-environment-climate) and Article 35 (Forest-environment),; compensation for constraints to management - Article 31 (Natura and WFD payments) and Article 32 (Areas of Natural Constraints payments); Capital investments in agricultural, forestry or environmental infrastructure - Article 18 (Investment into physical assets), Article 19 (Restoring potential after damage by natural disaster), Article 20 (Farm and business development), Article 21 (Basic services and village renewal), Article 22 (Investment into forest development), Article 23 (Afforestation and creation of woodland), Article 24 (Establishment of agro-forestry); , Adding value to environmentally sustainable produce - Article 17 (Quality schemes); Training, information and advisory - Article 15 (Knowledge transfer and information), Article 16 (Advisory services, farm management and relief services), and Article 20 (Farm and business development); innovation, research transfer and cooperation - Articles 36 (Co-operation), Article 42 (LEADER), and Articles 53, 61 and 62 (European Innovation Partnership).

[85] The six objectives are as follows: Fostering knowledge transfer and innovation; Enhancing competitiveness; Food chain organisation and risk management; Restoring, preserving and enhancing ecosystems; Promoting resource efficiency and transition to a low carbon economy; and Promoting social inclusion, poverty reduction and economic development of rural areas, ibid.

[86] Conclusions of the European Council (7/8 February 2013) as regards the Multiannual Financial Framework.

[87] Ibid

rural development budget back to Pillar 1, which could reduce the amount of funding available under Pillar 2 for supporting measures for water and soil.

Key stages for integrating water objectives into the CAP Pillar 2

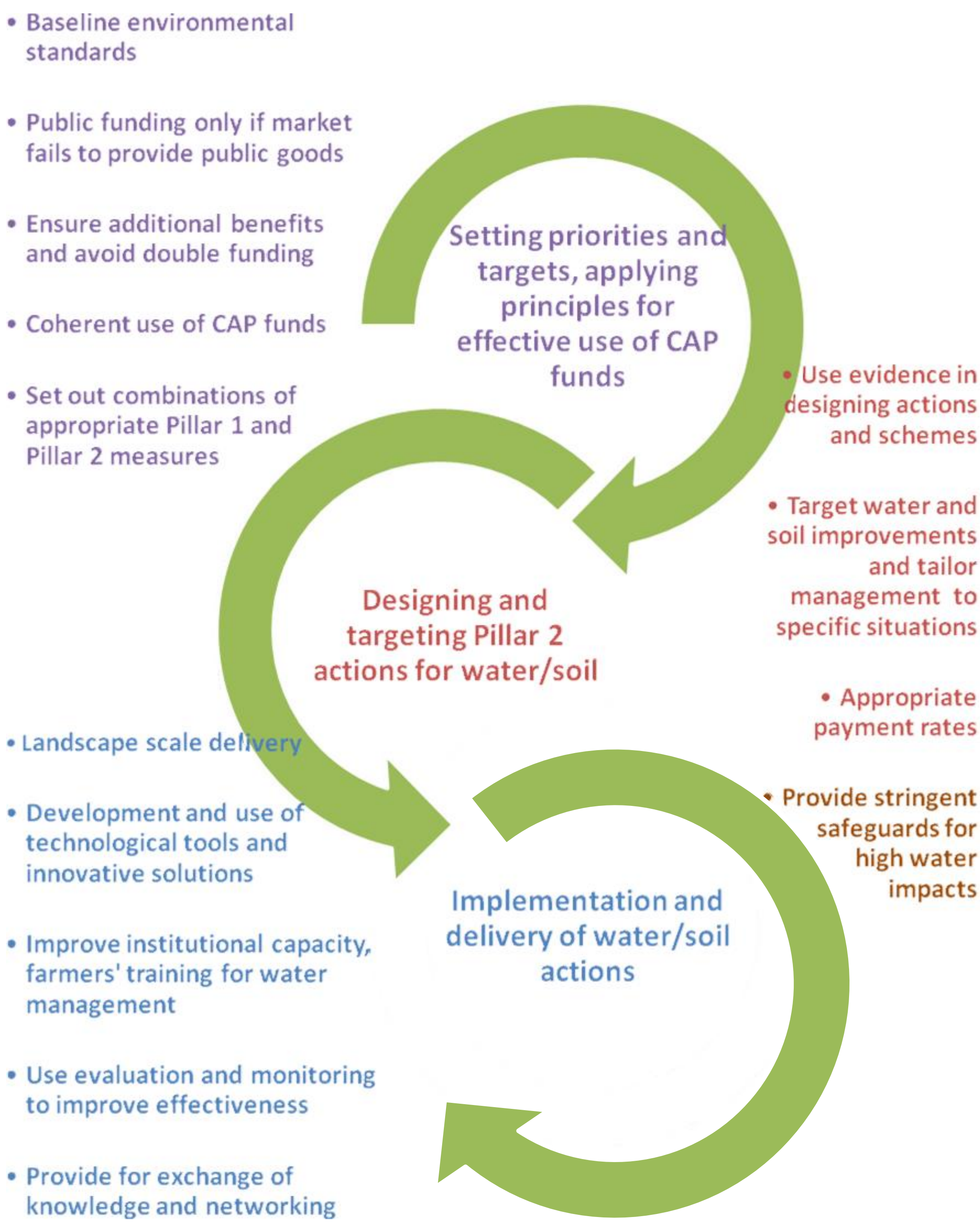
Policy options to improve the use of Pillar 2 funds for better protection of water and soils exist in different stages of the rural development policy cycle. These are relevant to every RDP and they should be pursued in an integrated way.

Figure **4** illustrates the stages. They include:

- Setting of funding priorities and water targets in Pillar 2, and applying principles for the effective use of the EU funds across the relevant policy instruments;
- Designing rural development programmes (RDPs) based on ex-ante analysis including assessment of environmental needs; targeting RDP actions and schemes to specific water and soil impacts; and
- Implementation, monitoring and evaluation.

Strengthened process of monitoring and evaluation, based on evidence and data targeted to specific environmental objectives, is embedded in the revised approach to programming, monitoring and evaluation (ENRD, 2012c). The details are expected to be included in implementing rules, to be published in 2014.

Figure 4: Key stages of rural development policy cycle for the integration of water and soil objectives



Source: adapted from Allen *et al*, 2012

5.7 Recommended options

Previous sections noted that agriculture is one of the key drivers influencing the state of Europe's water bodies and soils, as well as demonstrating a considerable potential in European agriculture to address continuing issues. Based on our assessment of effectiveness of CAP measures in the 2007-2013 period, this section sets out several options for improving soil and water management in the EU. It presents the recommended options, while distinguishing priority options from those that are required to underpin the priority actions, termed 'supporting' options. Table 11 below presents an overview of all recommended options.

Table 11: Options for the provision of improved water and soil benefits through the CAP measures

Priority options	Initiated/implemented by whom	Urgency
Fully implement and enforce the existing legislative framework at EU level	River basin authorities, national authorities, farmers, water companies and others	Medium to long term
Ensure that CAP cross-compliance requirements relating to water and GAEC standards relating to soil are strengthened and appropriately enforced	EU policy makers, national and regional authorities, managing authorities, paying agencies, farmers	Short term[1] to medium term
Use RDP funds for capital investments only when significant benefits for water and soils are demonstrated; use stringent safeguards and eligibility requirements for water savings	EU policy makers, national and regional authorities, managing authorities, paying agencies, NGOs and others	Short term[2] to medium term
Use RDP funds for land management only when significant benefits for water and soils are demonstrated or in priority areas; avoid double funding	EU policy makers, national and regional authorities, managing authorities, paying agencies, NGOs and others	Short term[2] to medium term
Ensure that the 2017 and 2019 enhanced CAP reporting demonstrates the outcomes of Pillar 1 greening measures and RDP support for water and soils	EU policy makers, national and regional authorities, managing authorities, paying agencies, monitoring and evaluation networks	Short to medium term
Supporting options		
Improve the design and implementation of CAP policies relating to water objectives; develop appropriate combinations of Pillar 1 and Pillar 2 measures for water and soil benefits		

Strengthen the effectiveness of monitoring and evaluation in relation to soils and water, by setting clear objectives and associated criteria for measuring success
Improve advice, institutional capacity, networking and sharing of good practices in relation to water and soils
Enhance coherence of national and regional strategies which include land-based measures; and coherence in the use of CAP and other EU/national funds for water and soils

Notes:

1. Urgent action is needed to ensure the cross-compliance framework includes appropriate soil and water measures since the negotiations on the proposed CAP Regulations between the Parliament, Council and Commission will be finalised by end June. Once the framework is agreed, action is needed at the Member State level to apply the measures in the most effective way.
2. Urgent action is needed given the advanced programming phase in Member States.

All the above recommendations are linked to those proposed in the Commission Blueprint to Safeguard Europe's Water Resources of November 2012. It is important to note that we consider the options developed in this report to be consistent with the proposed actions of the Blueprint. However, the Blueprint focusses on the EU level only. By contrast options recommended here also address potential actions to be taken by national and regional authorities, paying agencies, farmers, foresters and private businesses, and NGOs.

- **Priority option 1: Ensure that CAP cross-compliance requirements relating to water and GAEC standards relating to soil are strengthened and appropriately enforced**

Basic soil and water management should be better integrated into the CAP's cross compliance requirements and more rigorously enforced. The SUPD and the WFD should be included in the revised list of SMRs for the 2014-2020 period. Basic actions (permanent vegetation cover, contour ploughing, buffer strips) should be more systematically applied by Member States under the GAEC framework and these requirements subsequently enforced. The proposed new GAEC standards for soil organic matter and the protection of carbon rich soils and wetlands are also critical (see discussion in Section 5.2). Training and advisory should play a role in improving farmers' understanding of the sustainability benefits of the GAEC standards for the resource base of agriculture and associated ecosystem services, including food production. Minimum control rates for cross compliance should be considerably increased in target areas at risk, such as Nitrate Vulnerable Zones, polluted river basins or areas with pesticide pollution, and detailed analysis of non-compliance should be required.

- **Priority option 2: Use RDP funds for capital investments only when they demonstrate significant benefits for water and soils; use and enforce stringent safeguards and eligibility requirements for water infrastructure investments**

Funding to improve sustainable water use, water efficiency on farms and water quality should be assessed carefully against anticipated benefits for water and soils. Sometimes these capital investments can be driven primarily by economic objectives and have low additional benefit compared to investments that would have taken place without support. Therefore only infrastructure investments with demonstrated high water savings or water quality improvements merit public support. Funding for irrigation projects is a good example. Such projects should be assessed against stringent eligibility requirements, with water savings criteria, and their actual outcomes for water should be rigorously monitored. The eligibility requirements set out for irrigation in the proposed Rural Development Regulation will be a welcome improvement, if approved. In well considered situations where upfront costs are a barrier to the capital investment into new infrastructure on farms, for example in manure storage, public support is justifiable. Other instruments, eg payments for ecosystem services, voluntary schemes and financial instruments can be explored as alternative incentives for water infrastructure investments with shallow benefits.

- **Priority option 3: Use RDP funds for land management only when significant benefits for water and soils are demonstrated or in priority areas; avoid double funding**

RDP funds to land based management for improved water and soil outcomes should be made available only where significant benefits are demonstrated. In the CAP, these could be agri-environment-climate actions (which should build on requirements applied across the EU through green payments and cross-compliance) and WFD payments. Where synergies for different environmental objectives can be achieved, schemes should be designed for multiple benefits. For example certain demanding interventions such as land use conversions to grassland or rewetting of peat soils critically depend on agri-environment-climate (AEC) support. Double funding must be avoided. As well, the use of CAP for remedial actions for water pollution from farming, eg through improved manure management should be avoided. For these actions, the polluter pays principle applies. Dissipating constrained AEC allocations on business as usual management or basic soil practice should be avoided wherever possible[88].

- **Priority option 4: Strengthen the effectiveness of monitoring and evaluation in relation to soils and water, by setting clear objectives and associated criteria for measuring success**

The existing monitoring and evaluation framework in the CAP needs strengthening in relation to water indicators. There need to be clearer objectives set for water and soils by Member States, with specific targets and means of ascertaining success identified. Water use indicators (eg water exploitation index) can be used to identify areas with high ratio of water scarcity and water abstraction. In these areas eligibility of all expenditure into water efficiency should be seriously examined and its outcomes for water carefully monitored. At EU level detailed research in relation to measures aimed at water, and their interactions with other environmental objectives, eg, soil and

[88] Large amount of current AE support has been used eg for grass cover in vineyards and reduced tillage, ie actions that should be part of the baseline requirements or are very close to the baseline.

biodiversity, is lacking. Better data need to be developed on cost-effectiveness of measures relating to water benefits and to synergistic potential outcomes for water and soil.
More emphasis should be put on collecting information on the effectiveness of safeguards, for example the actual outcomes of afforestation projects aimed at water benefits.

- **Priority option 5: Ensure that the 2017 and 2019 enhanced CAP reporting demonstrates the outcomes of Pillar 1 greening measures as well as RDP support for water and soils**

The environmental elements of the revised CAP, most notably Pillar 1 greening measures, will be finalised in the negotiations between the Parliament, Council and Commission in the coming months. In the future, the environmental impacts of the new Pillar 1 green measures should be rigorously monitored alongside those of measures used under Pillar 2 and should be incorporated within the enhanced reporting envisaged in 2017 and 2019 on the use of CAP expenditure[89]. This would ensure that information is available to inform any changes in measure design or delivery needed either during the current programming period or beyond.

- *Supporting option: Fully implement and enforce the existing legislative framework at EU level*

Several existing Directives target improvements in water management in agriculture (the Nitrates Directive, Sustainable Use of Pesticide Directive - SUPD, Water Framework Directive -WFD). If these regulatory provisions have been well implemented on farmland and other land types across the EU, the impact of agriculture on water should diminish. However, there are issues with slow or incomplete implementation, in some situations the requirements of land-based measures are weak or their territorial focus is insufficient. Clarification is needed in particular for requirements under the WFD, so that the associated RDP measure to help with implementation (WFD payments) can be used. A particular problem is the vague requirements on water metering in RBMPs which have to be addressed through water policies first before these measures can be built on through grants for water saving measures in RDPs.

- *Supporting option: Improve the design and implementation of CAP policies relating to water and soils; develop appropriate combinations of Pillar 1 and Pillar 2 measures*

The two pillars of the CAP have different purposes but it is important that potential synergies between Pillar 1 and Pillar 2 measures should be used to benefit water and soil objectives at farm level. CAP measures should target concrete water or soil objectives corresponding to specific needs in the identified risk zones. Agri-environment-climate funding should build upon basic actions applied across EU farms through greening and cross-compliance and focus on advanced management with additional environmental benefits. Payments need to be set at appropriate levels, which is particularly important where market drivers (eg, in highly productive farming systems) and other policy drivers (eg, for expansion of biofuel crop production) threaten water quality and water availability. An integrated package of targeted support from both Pillars of the CAP should be developed for extensive farming systems that are already delivering high levels of water and soil benefits, but have low economic viability. This will help support their economic viability, and thereby continued provision of environmental benefits.

[89] Article of the proposed financing and monitoring Regulation COM(2011) 628/3, under negotiation with the European Parliament and the Council.

- *Supporting option: Improve advice provision, institutional capacity, networking and sharing of good practices in relation to water and soils*

There is a need to make full use of direct advice provision to farmers and land managers as this has been shown to be the most effective way of spreading information on sustainability issues. As well, there should be improvements in capacity at all levels relating to co-benefits or trade-offs between different environmental objectives, including water and soil, and to the effectiveness of multi-functional actions. This should ensure that when measures or management actions targeting different objectives have to be prioritised, conscious decisions are made with a full understanding of impacts. Engagement between existing networks such as ENRD and new EIP networks of researchers, environmental and agricultural stakeholders and farmers should be promoted.

- *Supporting option: Enhance coherence of national and regional strategies which include land-based measures, and coherence between the CAP and other EU and national funds for water and soils*

National or regional strategies are being developed or foreseen in relation to a range of environmental objectives, with direct or indirect effects on the management of water resources in agriculture (eg, land-based measures in river basin management plans, Nitrates Action Programmes and National Action Plans for pesticide measures, plans on natural water retention measures, drought management plans, flood management plans, climate adaptation strategies, biodiversity strategies, and possibly future green infrastructure strategies). There is a need to optimise coherence of these measures at national and regional levels where these strategies interact and affect agriculture and where pressures on water from agriculture interact with pressures from other economic sectors. Farms and stakeholders in rural areas that provide actions with water and soil benefits through the use of Pillar 2 support are often beneficiaries of other types of support, eg, other EU and national funds, alongside Pillar 1 direct payments. It is important to maximise synergies between these support streams and avoid harm to water resources through the combined effect of this mix of support (which may include training and advice).

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A summary of the study is also available.

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