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

Study summary

Science and Technology Options Assessment

STOA

The STOA project 'Sustainable management of natural resources with a focus on water and agriculture' was carried out by the Institute for European Environmental Policy, BIO Intelligence Service and the Ecologic Institute.

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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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1 INTRODUCTION AND OBJECTIVES OF THE STUDY

Water resources are essential for all sectors of the European economy, particularly for agriculture. 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. Climate change is expected to exacerbate existing pressures on water such as more frequent and more severe droughts and floods, affecting agricultural soils, and requiring adaptation by water users, farms, regions and Member States. This study therefore provides 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 to address these issues. It has three focus areas:

- **Sustainable water use and water efficiency**, while highlighting issues linked to agriculture and other sectors in rural areas;
- **Agricultural land management** with soil and water benefits; and,
- **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[1].

Water issues are different in each Member State, but reducing the pressure on water resources is important throughout the EU as there may be consequences both upstream and downstream, with associated benefits for ecosystems (eg on biodiversity), the 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 and farm management are critical for maintaining the natural resource base, and 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 main focus of this study was on the **sustainable water use and water efficiency** and to assess the potential role of **scientific research, technologies and good practices**. The potential impacts of policy options for sustainable water use and water efficiency on other environmental media, such as soil and biodiversity are also included. Technologies and practices relating to water quality are outside the scope of this part of the study. A second study area focussed on **agricultural land management with soil and water benefits**, the main objective being 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. The objective of a third study area focussed on **CAP measures** and assessed 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. 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.

[1] The next programming period will see significant changes in the CAP, however, since the proposed post-2014 policies have not been finalised, they are not analysed in detail.

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[2]. At an EU level, actions on this issue were strengthened by making it one of the seven flagships of the Europe2020 strategy in the 2011 Communication 'Roadmap to a Resource Efficient Europe'[3]. The roadmap describes priority actions for 2020 and long-term targets to 2050, with water being one of the key natural resources targeted. Water has grown in policy significance with the adoption of the Water Framework Directive (WFD) in 2001[4], and with the publication of the Communication on water scarcity and droughts in 2007[5]. The recently published Blueprint to Safeguard Europe's 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. On soils, 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[6].

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[7]. Measures under the Sustainable Use of Pesticide Directive and Water Framework Directive can also increasingly diminish the impact of agriculture on water[8]. 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). 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.

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

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

[4] 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.

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

[6] 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.

[7] 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.

[8] 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. It is of note that the average consumption varies 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 of consumption in Northern European countries.

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 from polluted effluents).

With 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 drought events likely to occur more often in the 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 to prevent and mitigate 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 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 have been introduced into the CAP since 1990s to promote sustainable farming, they have been unable to fully mitigate the negative effects on water and soil resources. Important challenges still need to be addressed for the resource base to be maintained for future food production, as well as for the provision of environmental public goods (Dworak *et al*, 2009; Stoate *et al*, 2009; ENRD, 2010b).

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 Member State 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.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 impacts 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.

A group of Member States identify changed or irregular water flows in river basins as an issue. Several 2007-20013 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).

The challenges to water frequently go 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 proportions of soils sensitive to soil erosion and, at the same time, high proportions 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).

3 SUSTAINABLE WATER USE AND IMPROVED WATER EFFICIENCY

Water is recognised as an important resource and several policies aim to ensure its sustainable and efficient use in the European Union. The recent 'Blueprint to safeguard Europe's waters' (November 2012) highlighted the importance of this precious resource and proposed ways to improve on current trends. Although the Water Framework Directive (WFD) sets the target to achieve good ecological and chemical status of water by 2015, the current prospect is that despite good progress since the implementation of the Directive, the target will not be met (EEA, 2012a).

A key issue in addressing the sustainable use of water and improved water efficiency is that there are many users that rely on water, many stakeholders are involved and there are different issues at play in each river basin. This calls for a variety of solutions in which collaboration between stakeholders and administration at different levels play a key role. In Mediterranean Member States, irrigation is a key driver of water use and thus a major theme of this project is the ways in which sustainable water use and improved water efficiency in the EU is promoted, particularly in agriculture. The study focuses on three key options for improving sustainable use of water and improved water efficiency. These are:

- Scientific research;
- Technological tools; and,
- Good policy practices, including water pricing.

Water issues are mostly linked to the use of blue water (coming from surface or groundwater bodies) as it is abstracted from the natural environment and results in environmental impacts. The issues linked to water are local, such that the use of water in a rainy area will not have the same impacts as it would in a dry area. However, there are also significant cross-border effects and transnational data and information needs. Also, the issues linked with water are seasonal; generally in the summer both availability and demand are higher than in the winter. The impacts will also depend on the demand for water, whereby single-users typically have more freedom than if the water is used by many stakeholders with the latter requiring that trade-offs are implemented in case of scarce periods.

Three main solutions are available to secure the sustainable use of water. The first is to reduce losses, such as water lost during transport or storage and ensure efficiency of water use, for example by using more efficient irrigation systems or by introducing efficient sanitation devices. The second aims to use alternative sources of water (ie alternatives to blue water) so that water use can continue even where blue water is not available; this is typically the case of grey water use but can also apply to rainwater harvesting, eg on farms, for later use at periods of low rainfall. The third concerns the efficient allocation of water to users so as to ensure equitable access for legitimate uses of water. These main types of solutions have been evaluated in the study by examining research, tools, and policy practices that are relevant to water use and water efficiency, particularly with regards to agriculture but in other sectors too. The range of relevant approaches highlighted in the study has been identified on the basis of literature reviews. Four types of approaches have been assessed in detail and are illustrated with one technology and its water benefits. Additional approaches are also presented but more briefly. Note that approaches relating to water quality are outside the scope of this part of the study.

3.1 Scientific research on sustainable water use and on improved water efficiency

EU research and innovation on improved water use is essential to guarantee future improvement for how water is managed in the EU and plays a fundamental role in meeting future water challenges. Although there is no comprehensive EU scientific agenda on available water, water is an important topic of EU research. On-going research initiatives on 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. In addition, the recently launched European Innovation Partnerships (EIP Water and EIP Agriculture) will provide an essential platform for science and interested stakeholders and can ensure that scientific research is useful and effectively communicated to stakeholders and farmers, while also giving them the opportunity to influence research.

Although much research on water is ongoing, there are still many data gaps identified in the study, for example in the area of water quantity and the calculation of ecological flows. Other research needs relate to specific aspects of water availability, water re-use, water quality, soil functionality.

3.2 Innovative technologies and options for sustainable water use and improved water efficiency

The innovative technologies and options for improved water use and efficiency are many, and include technological and non-technological options. This study has categorised the types of technologies and options into:

- Monitoring of water use;
- Alternative water sourcing such as rainwater harvesting and on-farm storage;
- Agricultural land management practices;
- Conveyance technologies such as canal lining to reduce leaks;
- Rating tools and standards;
- Precision irrigation techniques; and
- Decision-making support tools for water savings.

The study offers a more in-depth evaluation for remote sensing, wastewater re-use, irrigation scheduling tools and conveyance efficiency.

Although technologies and other non-technological options have the potential to improve the status of water bodies in the EU without jeopardising human uses, several factors need to be taken into account when their sustainability is evaluated. For example, the relevance of the technologies and options to local conditions and to different users should be considered. It is even more important to tailor agricultural land management options to soil, crop and climatic conditions. Any evaluation must also take account of the appropriate scale of benefits and risks. For example, ensuring that a more efficient use of water at farm level will not lead to an overall increase in areas under irrigation in the river basin can prevent an increase in water use. In addition, negative effects on soils and biodiversity should be considered, for example the analysis of benefits and risks for an innovation such as canal lining should examine the impact of reducing water in the soils of surrounding ecosystems.

3.3 Good policy practices

The examples of good policy practices investigated in the study focus on agriculture, urban areas, and the links between them 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.

It is important that policies allow for a strategic approach through coherence and long-term plans so that impacts arising from scarcity and floods are effectively managed through prevention, mitigation and adaptation.

The options currently used under CAP Pillar 2 for managing water quality in agriculture, for example the agri-environment measure, can also be used to target water quantities where necessary. Other instruments could include payment for ecosystem services, grants and loans for capital investments, water trading and irrigation advisory services.

In urban water management, good policy practices aim to address inefficient water supply by reducing leakage levels, improving efficiency of water use in buildings and increasing resilience to floods, etc. There are successful examples for all of these at a national level.

Linking rural and urban areas, policies on wastewater re-use can be very useful to improve the sustainable use of water. For example, such policies may require that water used for specific agricultural use (eg from washing machinery) or from urban wastewater systems, should be reused (with some level of treatment or with conditions on pollution limits) for certain agricultural activities such as irrigation. However, wastewater reuse currently faces issues of multiple unaligned standards and regulations being in use across the EU, sanitary issues being debated, and low public acceptance.

3.4 The role of water pricing

The introduction of incentives to water pricing is a key policy option that could reduce water use. The WFD already requires the principle of cost recovery for water services; but pricing should also respect the EU polluter-pays and user-pays principles. A range of pricing mechanisms exist, including tariffs, charges and taxes. Such mechanisms vary in their objectives, and may require additional actions, such as metering to implement pricing based on volumetric use.

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. Many successful examples exist of increased water metering in the EU, and there are also good illustrations available for the reduced water use linked to higher tariffs. While water pricing may be a strong tool for increasing resource efficiency, it is important to ensure that a well designed mix of instruments is used so that other incentives for water efficiency are also introduced. Indeed, bad pricing which may entail issues regarding affordability for low-income users, social equity, public acceptance, and the risk of illegal abstractions, should be avoided. These are all factors that must be taken into account when a pricing policy is being developed.

3.5 Recommended options

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 to reduce the 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 facilitating a significant behavioural change among water users.

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 better 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 and have 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. In particular, safeguards should be introduced into bioenergy policies so that biomass cultivation and extraction does not lead to further pressure on soils and water. While each sectoral policy has its own legitimate priorities, the sustainable use of resources should be an overarching goal. Water-, climate-, and biodiversity-proofing of the proposed river basin management measures and investments can be a useful tool.

Reduce water losses, increase water savings and efficiency

Several complementary approaches must be promoted to increase the sustainability of water use and meet the EU resource efficiency targets. 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, in order to reduce the implementation burden. Alternatively, the metering requirement could be subject to a preliminary risk assessment (eg using a WEI+ threshold value[9]). Second, improved water availability should be achieved through water re-use, rainwater harvesting and storage. Water re-use faces 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 and provide business certainty to farmers and water companies investing in this water saving measure. Third, improved land and soil management approaches will provide important water benefits (discussed separately below).

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 over 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 should be developed and used more widely, for

[9] WEI+ is an improved version of the Water Exploitation Index (WEI) which identifies the ratio of water extraction to availability. Thus it can measure stress on water resources from abstraction (EEA). WEI+ is an improved indicator under development.

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 urgently needed. The 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. These tools should be applied at all levels, from EU to local level, and should be customised to local conditions.

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 effects on water use in water scarce regions. Funding should be avoided for projects that may impede achievement of water priorities, 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.

Use supporting options for sustainable water use and water efficiency, such as:

- 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 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; and
- Examining the potential of existing environmental labelling schemes to incorporate water impacts in a coherent manner.

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

The second part of the study sets out agricultural land management actions which benefit levels of soil moisture and thus also water saving and actions for improved soil functions in particular for mitigation and adaptation to climate change. The assessment of the second category of soil actions focuses on preventing soil erosion and maintaining/enhancing soil organic matter (carbon stocks) in particular; but also evaluates their potential co-benefits and trade-offs with water quality and quantity, biodiversity, other environmental objectives and farm income. The relevant types of land management actions have been identified on the basis of a literature review.

4.1 Management actions for improved water availability

The study focuses on crop-related soil management actions that directly target sustainable water use and may save irrigation water. Such actions can aim to reduce demand for water by crops or to improve soil water retention, through:

- **Optimisation of crop patterns** (eg by changes to 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.

Each of these options have trade-offs, as they impact other aspects of crop management (eg weed management) and thus require tailoring to the individual farm. In addition to crop-related soil management, natural water retention measures may be implemented to reduce run-off and avoid water loss through soil evaporation. They could for example include creating buffer strips or restoring wetlands and could be applied to both farmland and wider ecosystems[10]. To stimulate the adoption of such practices, support to extension, information and training to farmers is needed.

4.2 Management actions for improved functions of soils

Agriculture, particularly in terms of soil management, has an important role to play in mitigating climate change, as well as facing the need to adapt to the future climate. Even though soils are under threat, there is currently no binding framework in place to protect soils at an EU level.

Appropriate soil management can deliver significant benefits for combating climate change by:

- **Preserving existing carbon stocks** in agricultural soils – a priority due to the amount of carbon currently stored and the time needed to develop new carbon storage;
- **Increasing sequestration of carbon in soils** – that has a good mitigation potential but has limitations such as saturation, non-permanence, displacements, verification problems; and
- **Reducing nitrous oxide emissions** associated with agricultural land use - a permanent and non-saturating solution.

In addition, good soil management practices have a range of benefits for helping farms to adapt to climate change, for example through preserving productivity, increasing water infiltration in soils etc. On the other hand, poor management of soils can increase greenhouse gas (GHG) emissions from soils, for example, due to fertiliser use, drainage and mineralisation of peatlands, soil erosion and

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

associated loss of soil organic carbon, or carbon dioxide emissions from deep tillage or land use change involving ploughing of grasslands.

The study identified the most relevant management actions that deliver soil benefits for both climate change mitigation and adaptation to climate change. They include:

- **Cropland management** (such as winter cover and catch crops, crop rotations with or without legumes, crop residue management, reduced tillage, prevention of soil erosion by permanent vegetation cover);
- **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).

The study identifies the benefits of such practices for mitigation and adaptation, but also their co-benefit to other issues such as water and biodiversity. Indeed, 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. Based on the different benefits and trade-offs associated with the different soil management actions, an overall evaluation of these actions has been prepared and is presented in the table below.

Table 1: 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	↑↑	↑↑	↑		

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
Grazing land management					
Optimising grazing intensity	↑	↑↑	↑		
Length and timing of grazing	↑	↑	↑	↓	
Grassland renovation[11]	↑	↑	↑	↓	
Cross-cutting options					
Buffer strips	↑	↑↑	↑↑	↓	
Permanent pasture/ no conversion to cropland	↑↑	↑↑	↑↑	↓	
Conversion of arable land to grassland	↑↑	↑	↑↑	↓	
Maintaining and restoring wetlands	↑↑	↑↑	↑↑	↓	
Set-aside/ Ecological focus area	↑↑	↑↑	↑↑	↓	↑
Agroforestry	↑↑	↑	↑		
Woodland creation	↑↑	↑↑	↑↑	↓	↑

Note: ↑↑ Strong co-benefits ↑ Medium or sometimes co-benefits, ↓ Trade-offs exist

4.3 Recommended options

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. Two specific types of management approaches are critical. First, requirements for permanent vegetation cover should be applied more consistently under the national standards for good agricultural and environmental condition (GAEC) – this would be highly effective in combating erosion. Second, there is a need to maintain and restore wetlands, wet meadows and floodplains. This has valuable benefits for natural water retention, habitats and climate regulation, particularly 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 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. The dissipation of large amounts of agri-environment-climate budgets on basic soil management practices should be avoided.

[11] see also conversion of arable land to grassland

Strengthen soil management requirements in the GAEC framework and introduce EU-wide framework for soils

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 as well as soils containing high SOM such as peatlands and wetlands where the risk of large carbon losses is highest. The reinforced GAEC standard for SOM should be retained in the revised framework as currently proposed, so that it can drive improvements in soil management across the EU. The GAEC for the protection of carbon rich soils should be re-instated. Since land and soil management often have important co-benefits for water retention in soils and the water infiltration capacity of soils, the adoption of an EU-wide framework for soils, such as a Soil Framework Directive, is an urgent priority.

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. These tools may then be used to target soil management schemes to the specific soil needs (as determined through need analysis) in the identified 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. 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.

Use supporting options for land management with water and soil benefits, such as:

- 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 to improve basic soil practices;
- Raise public awareness of the relevance of soil management to tackling climate change; and
- Address consumption habits by examining the potential to integrate soil impacts into existing certification schemes and labels in a coherent manner.

5 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. The principal CAP measures that protect water and soils are cross-compliance under Pillar 1 and the agri-environment measure under Pillar 2. There is a range of additional measures that can also be used to deliver benefits for water and soils, both within the CAP framework and outside of it. The CAP reform offers further 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.

5.1 Pillar 1 measures

The requirements and conditions set out for farmers under cross-compliance have both direct and indirect potential impacts for water and soil management. Farmers that are in breach of the rules are penalised by the reduction or removal of their direct payment. The pre-2014 framework for Good Agricultural and Environmental Condition (GAEC) consists of eight compulsory standards and seven optional ones which are tailored according to Member State characteristics. The compulsory standards which target water benefits are the establishment of minimum buffer strips along water courses (implemented from 2010) and control of authorised water use (introduced in 2012). The other standards directly target soils and may result in indirect benefits for water, these are: minimum soil cover; crop rotations; maintenance of landscape features; and retention of terraces. 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). Another instrument with potential to have direct benefits for water and soils under Pillar 1 is Article 68. The Farm Advisory System is also highlighted as having capacity to indirectly benefit water and soils. Member States are legally required to set up a Farm Advisory System to offer farmers advice on cross-compliance, but farmers' use of the service is voluntary.

5.2 Pillar 2 measures

Under Pillar 2, a large range of measures exist that can be used to deliver direct benefits to water; some of these can target directly soils and thus lead indirectly to positive impacts on water. These measures and the types of actions that they support are summarised in the table below.

Table 2: 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
Water use – land management actions		
Water saving soil management Conversion of irrigated cropping to extensive dryland cropping	• Agri-environment (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 (213) • Agri-environment (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 (214)	Protect and improve water quality
Management of water flows – land management actions		
Wetland creation Wetland restoration Wetland management	• Agri-environment (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 (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 (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

The 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 fact that it is the only compulsory measure within Pillar 2 and that in some Member States it accounts for a considerable proportion of the overall rural development budget, it is highly important for sustainable land management. In 2007-2013, more than half of RDPs directly targeted **water quality** in their agri-environment schemes[12]. 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. Other agri-environment measures support **water availability**, eg through water saving management actions (catch crops, cover crops); reducing water use on existing crops; and the reversion of irrigated cropping to extensive dryland cropping. However, these schemes are infrequent and water availability has been most often addressed by capital investments. Agri-environment schemes for 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 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 has been most frequently addressed by capital investments.

Pillar 2 water infrastructure investments

Capital investments to support sustainable water use and water efficiency have been used in the majority of 2007-2013 RDPs. For example the Mediterranean regions and several other regions have used them to support improved irrigation technology. However, whether such grants deliver net water savings in practice remains to be seen. 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 outcomes achieved for water, but evaluations are lacking to date.

Other Pillar 2 measures

Support to organic farming, advice, training, information and LEADER participatory approaches are other key measures relevant for the provision of water benefits.

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

5.3 Other measures

Beyond the remit of the CAP, examples of other EU and national funding measures that could be accessed to protect water and soils include LIFE+, payment for ecosystems services (PES) and certification schemes. LIFE+, the EU funding instrument for the environment, offers co-financing for innovative pilot projects that aim to improve water availability, water quality and management of water flows through land management, awareness raising and adopting new technologies. PES can incentivise land users to adopt recommended practices to deliver water and soils benefits on the understanding that the beneficiaries of the ecosystem services pay them, as the provider (ten Brink *et al,* 2011). National and private certification schemes that refer to the land management aspects of the food supply chain can potentially offer benefits for water and soils, however this applies only where the scheme requirements go beyond the EU baseline.

Financial instruments used in tandem with Member State Rural Development Programmes (RDPs) is another funding option, comprising venture capital funds, guarantee funds and loan funds. In theory these financial instruments could be accessed to support the protection of water and soils; however, there have been used only in six countries and there are currently no environmental safeguards in place and there is insufficient evidence to determine their environmental impact.

EU Cohesion Fund and Structural Funds (ERDF) provide further funding opportunities, for capital investments in water infrastructure in particular.

5.4 Principles for effective use of CAP funds

In assessing whether new actions proposed to improve sustainable water use merit public support, one has to bear in mind the existing 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. The proposed changes for the forthcoming programming period (2014-2020) entail 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, alongside the inclusion of support for farmers in areas of natural constraint and coupled payments for farming or sectors in difficulty (to succeed Article 68). Three principles for effective funding have been identified which should guide CAP funding in the forthcoming programming period. These are:

1. ***Achieving additional benefits:*** 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. Only the environmental benefits over 'what would have happened anyway' merit public support. 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.
2. ***No double funding:*** In keeping with one of the fundamental principles of public expenditure in the EU financial regulations, costs for the same activity cannot be funded twice from the EU budget. This is a potential issue which has been raised in the CAP reform debate regarding potential overlaps between the proposed greening requirements and the land management schemes in Pillar 2 (Hart, 2012).
3. ***Measurable impacts:*** Funding incentives linked to established environmental needs and based on empirical evidence (European Court of Auditors, 2011; ENRD 2012c).

5.5 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. The Sustainable Use of Pesticides Directive should be retained in the revised list of SMRs, and the GAEC standards for the protection of groundwater against pollution and protection of soil organic matter in the revised framework, as agreed on in the plenary vote by the European Parliament. The WFD should be re-instated in the list of SMRs. Basic actions (permanent vegetation cover, contour ploughing and buffer strips) should be more fully enforced through the GAEC framework. 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, only infrastructure investments with demonstrated high water savings or water quality improvements merit public support. If approved, the eligibility requirements set out for irrigation in the proposed Rural Development Regulation will be a welcome improvement. 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. Where water infrastructure investments offer only shallow benefits, other instruments, eg, payments for ecosystem services, voluntary schemes and financial instruments, can be explored as alternative incentives.

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 or basic soil practices should be avoided.

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. Better data need to be developed on the

cost-effectiveness of measures relating to water benefits and to synergistic potential outcomes for water and soil.

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. Enhanced reporting in 2017 and 2019 on the use of CAP expenditure, foreseen in the proposed financing and monitoring regulation[13], is an important tool for this. It should be ensured that the reports adequately assess 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.

Use supporting options for land management with water and soil benefits, such as:

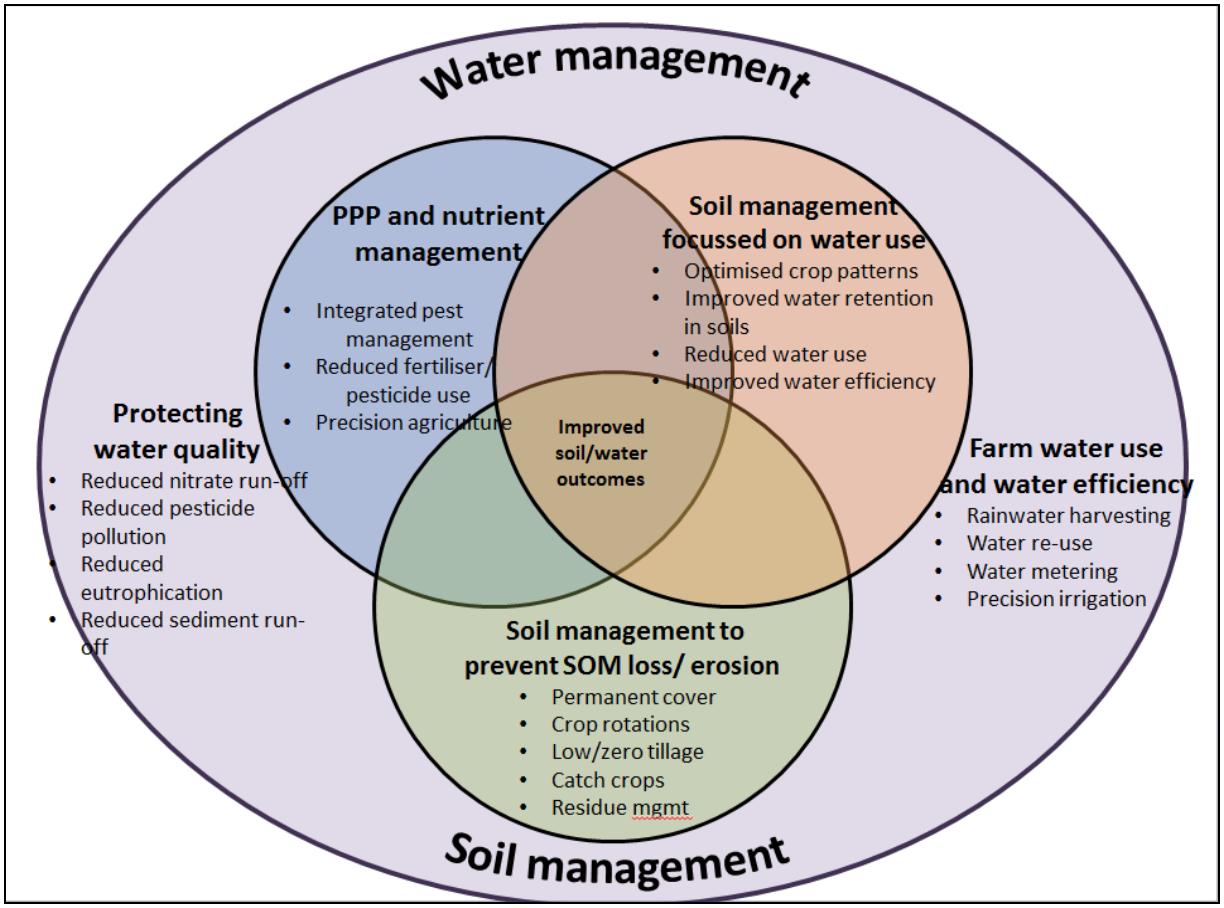
- Fully implement and enforce the existing legislative framework at EU level;
- Improve the design and implementation of CAP policies relating to water; develop appropriate combinations of Pillar 1 and Pillar 2 measures for water and soil benefits;
- Improve advice provision to farmers, institutional capacity, networking and sharing of good practices in relation to the use of CAP funds for sustainable outcomes for water and soils; and
- Enhance coherence of national and regional strategies that include land-based measures as well as between the CAP and other EU funds for water and soils.

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

6 CONCLUSIONS

This study has concluded 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. Depending on the level of environmental 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 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.**

This document summarises the findings and conclusions of the STOA study:
'Sustainable management of natural resources with a focus on water and agriculture'.

The STOA studies can be found at:
http://www.europarl.europa.eu/stoa/cms/studies
or requested from the STOA Secretariat: STOA@ep.europa.eu

In addition a short Options Brief is also accessible through the STOA studies website via this QR code:

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