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## Climate change mainstreaming in agriculture

### Natural water retention measures for flood and drought risk management

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## Summary

Many EU policies contribute to reducing flood and drought risks, which are projected to increase in many areas due to climate change. The EU Water Blueprint encourages a policy switch from dams, reservoirs, and other grey infrastructure to supporting natural water retention measures, or green infrastructure. Our estimates show that the costs of this switch can be significant for on-farm ponds; however, conservation tillage and (to a lesser extent) shelterbelts appear to be cost-competitive with reservoirs for storing water in the landscape. If the co-benefits, especially climate change mitigation, the reduction of land-use degradation and biodiversity, are taken into account, the cost advantage of these measures increases

## Introduction

The cost of floods, and the scale of droughts, continue to rise in the European Union despite more than a century of investments in levees, reservoirs, irrigation systems, and other infrastructure (OECD 2010). These growing costs can be attributed to climate change only to a limited extent at this time. Yet climate projections suggest significant increases in future risk across the EU (IPCC 2012), underlining the need for investing in drought and flood risk management today as a way of preparing for and, if possible, mitigating climate change in years to come. We examined the potential and challenges for mainstreaming flood and drought risk adaptation, with links to mitigation, into EU water and agriculture policies with a case study in the Warta river basin of Poland.

The research shows a wide mix of EU water and agriculture policies that contribute to flood and drought risk management. ***It also examines the cost-effectiveness and co-benefits of EU policies that support on-farm natural water retention***

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***measures (NWRMs) as an alternative to traditional investments in dams and reservoirs.***

The objective of NWRMs, such as natural ponds or wetlands, shelterbelts and changed tillage practices, is to slow down or reduce the flow of water downstream leading to a more natural flow regime within a catchment.

## **Many EU policies contribute to flood and drought risk adaptation**

The EU has a comprehensive portfolio of policies addressing flood and drought risk (see Figure 1). The most important are the:

- EU Common Agricultural Policy (CAP),
- EU Water Framework Directive (WFD),
- EU Floods Directive (FD),
- EU Water Scarcity and Droughts Strategy (WSDS), and
- Structural and Cohesion Funds.

There are many examples of how flood and drought risk adaptation measures, with links to mitigation, are mainstreamed into EU policy. For instance, the WFD and FD require flood and drought risk management plans and flood risk assessments to take climate change into account, although without specific targets. While the CAP does not directly address flood and drought risks, recent reforms present mainstreaming opportunities. For instance, the CAP cross-compliance regulations can require on-farm measures, such as constructing small retention ponds, planting shelter belts that reduce runoff, and changing tillage practices to hold moisture in the soil, which not only reduce

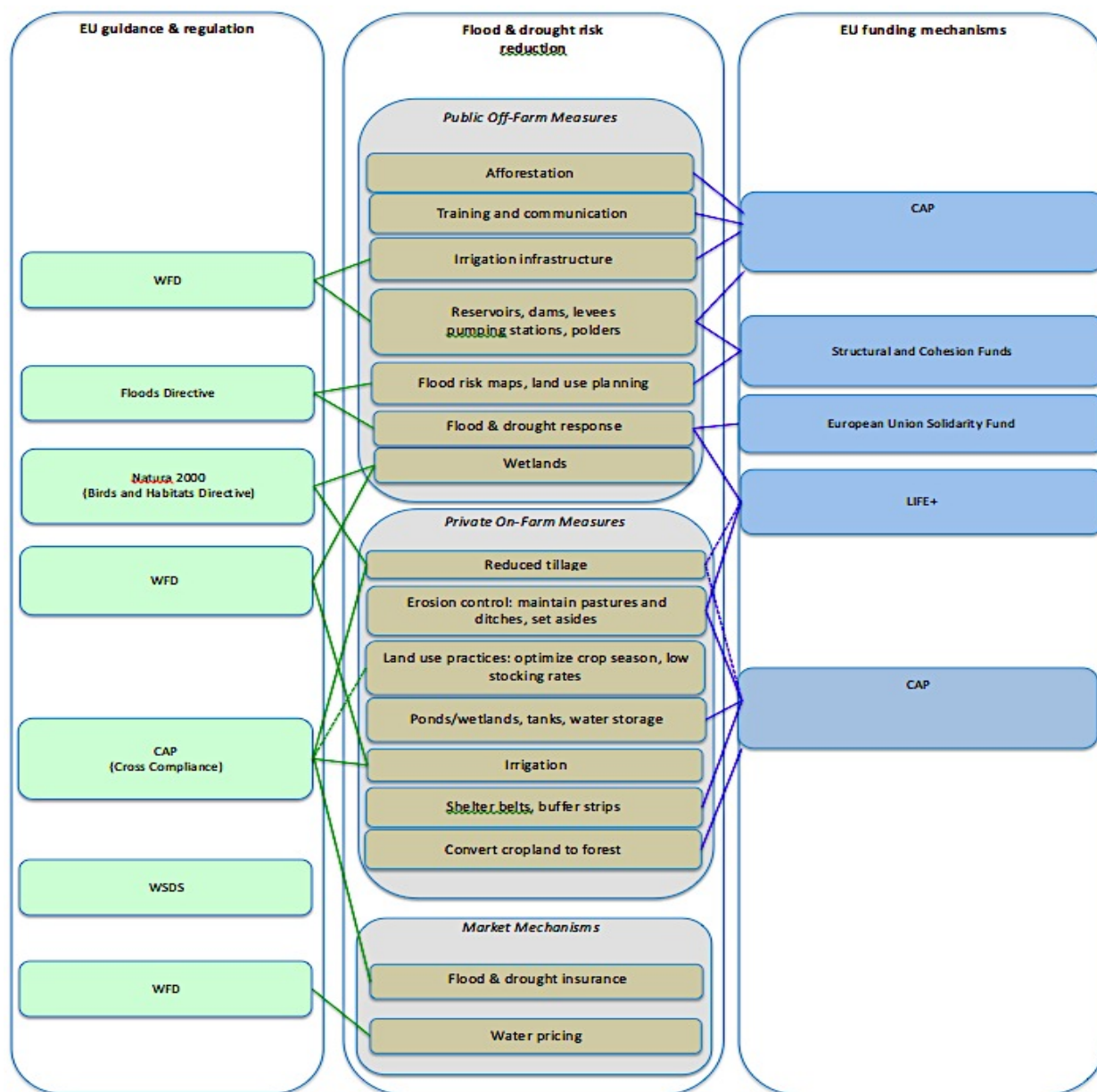
flooding downstream and provide water in time of drought, but also contribute to mitigation by enhancing carbon sequestration. CAP's Agro-Environment Program (AEP) can compensate farmers for making on-farm water-retention and other "green" infrastructure investments. Off-farm "grey" infrastructure measures, such as large reservoirs, are eligible for co-funding from the European Agriculture Fund for Rural Development (EAFRD) and the Structural and Cohesion Funds.

A pressing issue facing the Commission with regard to mainstreaming adaptation is better integration of this patchwork of CAP, WFD, the Structural and Cohesion Funds and other policy instruments currently available.

## **Cost-effectiveness of natural water retention measures (NWRMs)**

In its recent publication, *A Blueprint to Safeguard Europe's Water Resources*, the European Commission suggested switching priorities from grey to green infrastructure, and especially from dams and reservoirs to NWRMs. In the Warta region, and throughout Europe, authorities have historically responded to flood and drought risk with large water infrastructure projects. These are increasingly facing budgetary constraints, environmental concerns, and public opposition. Many stakeholders recognize the need for new reservoirs in the Warta region, but suggest these should be supplemented by on-farm natural water retention strategies, especially those that promote climate change mitigation.

**Figure 1:** EU policy instruments that mainstream flood and drought risk management.



To address this transformation, powerful policy integration tools are proposed for the Commission’s 2014-2020 Multiannual Financial Framework (MFF) that could greatly enhance the take-up of green infrastructure. The proposed commitment of 20% of the EU budget for climate mainstreaming in the MFF should

increase support for all water measures related to climate adaptation. Elements of ecological focus areas envisaged by the Commission proposal on the greening of CAP Pillar I could promote NWRMs, in addition to CAP’s Pillar 2 funds for regional development, and potentially the Structural and Cohesion Funds.

**Table 1:** Cost effectiveness of selected NWRM in the Warta region with non-quantified costs and co-benefits (climate change costs and benefits marked in bold).

Water retention measures	Costs/m3 water stored* or annual runoff reduced	Climate change mitigation and other significant non-quantified costs	Climate change mitigation and other significant co-benefits
<b>Large reservoir</b> (Wielowies Klasztorna) 49 million m3	€1.68 per m3 water stored	<b>Increased CO2 emissions (deforestation for construction)</b> Restriction of fish migration Reduction of groundwater levels downstream Social costs of displaced persons	<b>Decreased CO2 emissions from electricity production</b> Tourism Contribution to biodiversity Fisheries
<b>Large pond</b> (Warta data) 210,000 m3	€5.88 per m3 water stored	<b>Increased CO2 emissions (deforestation for construction)</b>	Contribution to biodiversity (including migration corridors) Landscape enhancement & recreation
<b>Small on-farm pond</b> (140 m3) (U.K. data)	€558.00 per m3 water stored	<b>Increased CO2 emissions (deforestation for construction)</b>	Contribution to biodiversity (including migration corridors) Landscape enhancement & recreation
<b>Shelterbelt</b> (Warta data)	€6.86 per m3 annual runoff reduced	Reduced crop acreage Retards satellite monitoring	<b>Sequestration of CO2</b> Contribution to biodiversity (including pollination) Increased yield from remaining crops Reduction of land degradation
<b>Switch to conservation Tillage</b> (U.S data)	- €9.20 per m3 annual runoff reduced	Increased pesticide use	<b>Sequestration of CO2</b> <b>Less fuel use</b> Contribution to biodiversity, pollination & water quality Increased agricultural productivity Reduction of land degradation

\*Estimates are based on construction and maintenance costs only. Among other assumptions (detailed in Deliverable 4.5), calculations are based on 30-year project life and discount rate of 5%. Estimates are preliminary and approximate.

But are NWRMs cost-effective? We compared the construction and maintenance costs of the Wielowies-Klasztorna reservoir with three on-farm measures: small and large ponds, shelter belts and conservation tillage. Preliminary estimates of the cost per cubic meter of water stored, or the annual reduction in runoff, along with non-quantified costs and co-benefits, are shown in Table 1.

The extent to which retaining water in the landscape helps prevent runoff depends on the free capacity of the water bodies and saturation of the soils.

Considering only investment and maintenance costs, preliminary estimates show that Wielowies Klasztorna is less costly for storing water in the landscape than on-farm ponds, with significant economic advantages over very small ponds. Moreover, it would require nearly 250 large ponds to store the equivalent water of the Wielowies Klasztorna reservoir. ***The economies of scale suggest that ponds are less appropriate as a drought and flood measure, although they may be economically justifiable as fish farms.***

***The cost advantage of the reservoir, however, may lessen when compared to the runoff avoided from shelter belts, and disappears altogether when compared to runoff avoided from conservation tillage.***

Not only does conservation tillage reduce runoff, but it also lowers labor and machinery costs.

Shelterbelts usually line roads and fields with trees and shrubs. Relative to cropland,



shelterbelts have a higher potential to reduce runoff and retain water in upland areas.

Photo: Oklahoma Forestry Department

The term *conservation tillage* refers to management practices that minimize the disruption of the soil's structure, reduce erosion, degradation, and potentially water contamination. Conservation tillage techniques are designed to leave a minimum of 30% of crop residue on the soil surface during the critical soil erosion period.



Photo: <http://climatetechwiki.org/content/conservation-tillage>

Estimating the cost advantage of reservoirs over shelter belts will require further research to compare “water stored” with “runoff prevented”. The advantage of reservoirs may be reduced or eliminated altogether if climate change mitigation, as well as other non-quantified costs (like reservoirs restricting fish migration) and co-benefits (like contributions to biodiversity and reduced land degradation) are taken into account.

## Valuing costs and co-benefits, including climate change adaptation

The non-quantified costs and co-benefits shown in Table 1, including carbon sequestration, illustrate the necessity of easy-to-apply measures that approximate their values in order to mainstream flood and drought risk reduction into a unified EU policy implementation. Methods exist for pricing non-market costs and benefits and eco-system services, but they are difficult to implement, especially in the uncertain context presented by climate change.

The FD and WFD state that uncertainty related to climate change should be presented transparently in flood maps, with climate change scenarios included in planning processes. According to the *EU's Climate Change & Water Guidance*, climate change is expected to be fully integrated into river basin management in future planning cycles. However, there continue to be great uncertainties in projecting climate change impacts on flood hazards over investment horizons relevant to water managers. This explains why climate change was not considered in assessing the flood risk in the cost-benefit analysis carried out for the Wielowies Klasztorna reservoir.

## Climate change and robust investments

Our estimates show that climate change increases flood hazards for the Warta region

after 2070 (nearly doubling) and drought losses after 2030 (30-40% increase). The uncertainty surrounding these estimates and other model results is, however, significant, with even the sign of the uncertainty being in doubt (-17% to +85% for floods). Robust policies that work well given a range of future scenarios are needed. For instance, water retention measures are robust for both growing flood hazard (increased precipitation) and for increased drought hazard (decreased precipitation).

## Policy implications

Our preliminary results show that “green infrastructure,” especially conservation tillage and (to a lesser extent) shelterbelts, appear to be cost competitive with “grey infrastructure” like dams and reservoirs for retaining water, and, in addition, they contribute to climate change mitigation, biodiversity and pollination, and reduce land-use degradation. Small and large on-farm ponds, alternatively, are hardly cost competitive with large reservoirs, but have co-benefits like promoting corridors for species migration and creating income from fisheries. Note, however, that a full comparison requires all estimates in terms of reduced runoff that takes account of soil saturation and other factors.

The Blueprint combined with the Commission's 2014-2020 Multiannual Financial Framework can promote the take-up of on-farm green infrastructure for managing flood and drought risk. The aim should be to prioritize investments and activities, taking account of future climate risk and the full range of costs and benefits. For this purpose, the Commission should consider providing guidance on valuing co-benefits of adaptation and mitigation measures in the agriculture and water sectors. There is also a

need for risk assessors to be given concrete guidance on how to assess and value distant future climate change impacts in present-day infrastructure decisions. Irreducible uncertainties in climate and hazard projections mean that policymakers should consider the benefits of flexible, no-regret strategies, which, as in the case of the Warta, adds emphasis to the potential value of supporting on-farm green infrastructure, like shelterbelts and conservation tillage.

## References

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The RESPONSES project addresses EU policy challenges by: developing new global low emissions scenarios, placing EU efforts in a global context; building an approach for assessing EU policies against mitigation and adaptation objectives and for developing alternative policy options; applying this framework in five EU policy sectors (water and agriculture, biodiversity, regional development/ infrastructure, health and energy), linked by a set of cross-sectoral integrative activities; and synthesizing the results to new policy strategies.

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