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Assessment of adaptation measures: Factsheets

Annex 11 to the Final Report

for the project

Climate Adaptation – modelling water scenarios and sectoral impacts (ClimWatAdapt)

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Report authors:

Martina Flörke, Florian Wimmer (CESR)

Cornelius Laaser, Rodrigo Vidaurre, Jenny Tröltzsch, Thomas Dworak, Ulf Stein (Ecologic)

Natasha Marinova, Fons Jaspers, Fulco Ludwig, Rob Swart (Alterra)

Carlo Giupponi, Francesco Bosello, Jaroslav Mysiak (CMCC)

CESR – Center for Environmental Systems Research

In co-operation with

Overview of the assessed measures differentiated into technical measures and supporting actions.

Technical Measures

Measure sub-category	Measure Code	Measure Name	Measure Description
Changing management or practices	M01	Water sensitive agricultural practices	Reduction of the water demand in agriculture by ways different from the irrigation techniques and efficiency.
	M02	Adaptation of Dredging Practices	The measure focuses on the adaptation of dredging practices to changes in erosion and siltation in rivers. Dredging methods or disposal options in use should be modified to ensure implementation with minimum environmental impacts.
	M03	Water sensitive urban design (WSUD)	Water Sensitive Urban Design (WSUD) is an emerging urban development paradigm aimed to minimize hydrological impacts of urban development on environment. In practice, the WSUD integrates storm water, groundwater water supply and wastewater management to protect existing natural features and ecological processes; maintains natural hydrologic behaviour of catchments; protects water quality of surface and ground waters; minimizes demand on the reticulated water supply system; minimizes wastewater discharges to the natural environment; and integrates water into the landscape to enhance visual, social, cultural and ecological values.
	M04	Managing Groundwater Recharge To Reduce Water Scarcity And Saltwater Intrusion Risk	MAR is a technique used in arid and semi-arid regions to recharge aquifers in a controlled way so that excess water can then be used later for water supply or environmental protection. A way of mitigating the threat of saltwater intrusion is systematically maintaining higher water table levels for groundwater, thus reducing the hydrological gradient from seawater.
	M05	Reducing freshwater demand for industrial cooling	Using recycled water for industrial cooling reduces freshwater demand, which will make power plants less susceptible to climate-induced changes to water availability.
Land use change and management	M06	Improved water retention	Increasing the water retention capability in rural areas aims either to increase the natural water retention capacity of a landscape or to increase the water storage capacity with man-made structures. Natural water retention can be improved by techniques like creating wetlands and increasing soil cover. Additional water storage capacity can be achieved with structures such as off-stream polders or flood retardation ponds. Winter water storage reservoirs reduce abstraction during the summer, increase flood storage capacity, and benefit wildlife. Compensation may facilitate implementation and operation.

	M07	Establishing wooded riparian areas	Vegetated and unfertilized buffer zones alongside watercourses act as a shield against overland flow from agricultural fields and reduce run-off from reaching the watercourse, thus decreasing erosion and the movement of pollutants into watercourses. Prevention of sea level rise and increased flooding, reduce potential for erosion in shore zones and lessen the impact on vegetation to worsen impacts of inundation.
Technical measures related to technical infrastructure	M08	Adaptation of existing dikes	The design of existing dikes can be modified to fulfil different purposes. Re-enforcing dikes and dams can increase their stability and resistance against dike breaching, e.g. by strengthening the inner core of the dike or improving the characteristics of the dike's surface that contribute to the overall stability of the dike. Dikes can also be re-enforced by heightening, broadening or by adding spatial components. Dike design can have the aim of allowing water in certain conditions to surpass them without breaching. This is usually achieved by strengthening the inner wall of the dike and by broadening the dike. Surplus water will be pumped away. Reallocation of dikes (spacing) will create a wider floodplain with an enclosed retention area.
	M09	Soft coastal defences	A new paradigm of giving space to water and using natural landscapes to aid coastal defence infrastructure is emerging. Example measures are: • Allowing the sea to invade former dune slacks in certain sections of the coast. • The strategic construction of reefs along a coastline to reduce the strength of waves and, thus, the erosion of the coastline by the sea. • Applying sand suppletion to maintain the amount of sand present in the “foundation” of the coast (beaches and underwater in the shallow bank zone). • Managed retreat of coastal defences. • Widening protection structures instead of making them higher and stronger. Introduction figure on alternatives for traditional coastal defence engineering solutions. (source: http://www.comcoast.org/)
	M10	Safe Havens In Inland Waters And Additional Temporary Moorings	Alter existing havens or construct new ones to address safety issues related to the increased frequency of strong stream conditions, floods and low water levels. Additional moorings address safety issues concerning the increased frequency of strong stream conditions as a result of high water levels or of periods with low precipitation and low water levels.
	M11	Leakage control in water distribution system	Controlling water leakage from extensive and aging municipal and agricultural water distribution systems.

	M12	Enhancing or increasing the water storage capacity of reservoirs	Reservoirs can contribute to redistributing available water resources in volume, time and space. Water that is stored during high flows can be distributed in dry periods to supply water for additional irrigation can make a region less vulnerable to droughts. At the same time, large reservoirs that have the capacity to store part of the high flows and release them during lower flow periods reduce peak flows and can prevent a region from flooding.
	M13	Recycling of treated water	Recycling of water for non-drinking purposes. Domestic water from baths, showers and sinks (grey water) can be re-used for toilet flushing, laundry/dish washing and garden and irrigation. Waste water can be used for irrigation, glasshouses; industrial processes can be designed to use water in closed circuits.
	M14	Desalination	Desalination is the process of removing salt from water to make it useable for a range of 'fit for use' purposes including drinking. Advancing technologies could render desalination more energy efficient and reduce operating costs. It could become a viable and weather independent alternative for urban drinking and non-drinking water supplies in the future.
	M15	Inter-basin water transfer	Shift of potentially large water volumes from a water abundant basin to areas outside of the donor basin where water resources endowment is low or very variable through year, limiting so economic growth.
	M16	Improving Irrigation Efficiency	A shift from gravity irrigation to modern pressurized systems (e.g. drip and sprinkler irrigation) and improved conveyance efficiency provide an opportunity for reduced water demand in irrigation.
Technical measures related to green infrastructure	M17	Water Sensitive Forest Management	Forest management measures can increase water yield, regulate water flow, and reduce drought stress for a forest e.g. during current and future low-flow conditions. Measures that address existing forests include (1) reduced density of stand stocking; (2) shorter length of the cutting cycles; (3) planting hardwood species; (4) regeneration from seedlings rather than sprouts (5). Afforestation, in particular near watercourses, brings benefits for the regulation of water flow and the maintenance of water quality, reducing the intensity of floods and the severity of droughts. The digital classification of forest sites can be used for analysis, consultation, and developing adaptation recommendations.
	M18	River restoration	The measure focuses on the increase of flow capacity of the river system during flood events, and/or the reduction of the speed of water flow. This also helps to increase habitat quality and groundwater recharge.
	M19	Sustainable Drainage Systems (SUDS)	Drainage systems can be improved by shifting to Sustainable Drainage Systems (SUDS), whose installation mimics natural drainage patterns to ease surface water run-off, encourage the recharging of groundwater, provide significant amenity and wildlife enhancements, and protect water quality.

Support Actions

Measure sub-category	Measure Code	Measure Name	Measure Description
Risk prevention	SA01	Spatial Decision Support System (sDSS)	A spatial decision support system (sDSS) can handle key tasks of water management such as administration, crisis management, and planning.
	SA02	Development and planning based on climate risk assessments	The Climate Risk assessment aims to assist authorities, investors, and planners in integrating the latest information on climate change impacts, possible adaptation response options, and investment selection criteria that take climate change into account into planning activities.
	SA03	Disaster risk reduction – emergency management	Emergency management comprises all activities to protect human life, property, cultural heritage and environment during hazard strikes, typically involving emergency response teams and facilities, and coordination mechanisms laid down in emergency plans.
Awareness/information	SA04	Information and knowledge management	Strategic monitoring on specific indicators and reporting activities provide baseline information that may indicate the inception of impacts. Early warning systems help decision makers and private individuals at all levels reduce the impacts on extreme climate events. The information should be reliable and timely available with a strong focus on the people exposed to risk in order to increase resource use efficiency. Information can be obtained from improved flood predictions and weather forecasts, from the state of waters and aquatic ecosystems in a region, from weather radar, and from satellites observations and can be collected and shared through related networks.
	SA05	Awareness and Capacity Building	This measure encompasses actions that promote awareness for the altered conditions under Climate Change. It strengthens the capacity of stakeholders affected by weather extremes from civil society groups and local and national governments to better address the impacts of climate change through their own involvement. Awareness and capacity building can address groups of people in a region affected by a particular climate change threat, groups of stakeholders, the general public, etc. The ultimate aim is to achieve behavioural changes. Actions which share information about ongoing impact assessments and adaptation activities will lead a wider range of organizations to think about climate-related problems.
Changing management or practices	SA06	Adapt the management of water levels in lakes, discharges in rivers, and inundation of wetlands to environmental needs	Human developments significantly alter water levels in lakes and wetlands and river discharge and this may cause significant environmental damage due to floods, water shortages, the accumulation of nutrients and toxins, and changes of habitats. Water level controls are management practices that may be the most socio-economically and environmentally balanced solution to protect threatened ecosystems and ecoservices. This management approach should be adapted on the basis of the best

			available information on climate variability and change and their impact on freshwater ecosystems in order to deal adequately with the increased flood and drought risks and improve the status of these ecosystems. In this process, substantial involvement of stakeholders in the formulation of the problems and their solutions should be envisaged, avoiding impasses in decision making, making water management as a guiding principle in spatial planning.
Economic and financial	SA07	Risk pooling and insurance	Risk pooling and insurance is the typical risk sharing/alleviating instrument. The insured pays a premium to the insurer that covers the risks regarding one or more variables and indemnifies only after the assessment of losses caused by climate change.
	SA08	Funding provision and subsidies	Provision of funding and subsidies (on products and practices) can spur behavioural change through incentives or disincentives, change conditions to enable economic transactions, or reduce risk. Rather than specifying a particular type of behaviour that the regulatee has to comply with, economic instruments create the economic incentives (e.g. price signals) to support drought and flood management.
Land use change and management	SA09	Transboundary flood management through spatial planning	Transboundary flood management projects bring representatives together from regional and national authorities, water boards, and other organizations. The goal is to decrease the impacts of floods through good spatial planning.
	SA10	Land use planning	Land use planning can be used in the case of droughts, scarcity, and flooding and can significantly affect the hydrological cycle of a region. Land use planning can influence water abstraction by particular sectors. Various measures, such as afforestation and sustaining wetlands, can reduce flood risk and make regions more resilient against droughts. Land use planning can also be used to reduce flood risks.
Management plans	SA11	Shoreline Management	Shoreline management has been introduced into coastal management practices since the 70ies of the past century (see for instance Washington State Shoreline Management Act adopted in 1971) giving way to holistic and sustainable practices of beach and shoreline management, including control of erosive processes and coastal flooding. Basic principles of shoreline management acquire an increased importance because of prospective of raising sea level rise under changing climatic conditions.
	SA12	Drought Management	Drought management and water conservation plans are planning instruments that contain measures aimed at the temporary and permanent reduction of water consumption or use. They help to identify and reduce societal vulnerability to drought by improving drought preparedness and reducing drought impacts. Drought and water scarcity knowledge systems capture, manage, analyze and display relevant meteorological, hydrological, agro-technical, social, and other data. This information can help to better forecast drought events and their associated impacts.

	SA13	Water conservation and abstraction plans	Water conservation and abstraction plans (WCAP) are multi-year plans that detail how the authorities responsible for granting water abstraction licenses will manage water resources at a catchment scale. The WCAP work by assessing the availability of water resources on a scientific basis and then taking stock of all water needs including the water demand of ecosystems in the future. The aim is to provide a framework for a licensing strategy which aids the sustainable management of water resources on a catchment scale. This can include consumptive (e.g. agriculture) and non- consumptive uses (abstraction for cooling purposes). Licenses are time-limited, requiring that WCAP are regularly updated and progressively integrated in other strategies and programs related to water. It is also important to elaborate a communication plan devoted to an efficient use of water consistent and coordinated with the organizations working on the issue.
	SA14	Implementation of a cross-sectoral adaptation and risk aversion strategy	The measure is aimed to establish national, state-wide or regional aversion strategy for all sectors that are related to climate change adaptation.
Regulatory	SA15	Water saving in building codes	New national standard for sustainable design and construction of new homes, which places strong emphasis on water conservation in households.
	SA16	Compulsory water restrictions and rationing	Water restrictions limit certain uses of water, for example, irrigation of lawns, car washing, filling swimming pools, or hosing down pavement areas. Water rationing includes a regular temporary suspension of water supply or a reduction of pressure below that required for adequate supply under normal conditions. Rationing is associated with equitable distribution of critically limited water supplies in a way that ensures sufficient water is delivered to preserve public health and safety. Both rationing and restriction that may be of a temporal or permanent character.

SPATIAL DECISION SUPPORT SYSTEM (sDSS)

Measure Number	SA01
Description	A spatial decision support system (sDSS) can handle key tasks of water management such as administration, crisis management, and planning.
Measure category	Support Action
Measure sub-category	Risk Prevention
Climate threat	Too much water (flooding, sea level rise, coastal erosion), not enough water (scarcity and droughts), deteriorating water quality and biodiversity.
Link to vulnerability	Addresses all impact indicators via sensitivity pressure indicator management practices.
Expert and stakeholder judgement	Subjected to a fast track assessment, the stakeholders assigned a middle priority and urgency for the measure.
Qualitative assessment based on literature review	Spatial DSS are a class of computer systems that combine the technologies of geographic information systems (GIS) and decision support systems (DSS) to aid decision makers and the broader public with problems that have spatial dimensions. They rely on graphical displays to convey information to users (Dymond et al., 2004). Spatial DSS can be used for addressing the need of both decision-makers and the broader public. When an sDSS has the latter function, it typically aims to provide information to the public, such as communicating the flood-risk determined for all real estate or plots of land in a particular rivershed. It can also be used to increase preparedness, provide capabilities to stakeholders, facilitate knowledge transfer, share environmental data, increase decision-making transparency, and improve communication among stakeholders (Levy et al., 2007; Sugumaran et al., 2004). However, Spatial DSSs are mainly oriented towards decision makers. They are used as support in decision-making for complex problems characterized by multiple (and conflicting) objectives, often involving numerous variables, competing alternatives, and value-laden judgments (Levy et al., 2007). The tool can adopt new capabilities as they are required (Dymond et al., 2004), and has the possibility of decision criteria being determined by users (Sugumaran et al., 2004). Their most typical use is in development planning to reduce flood risk; related uses are flood emergency management (e.g. management of reservoir water to minimise downstream flood impact) (Shim et al., 2002), and emergency resource allocation during floods (Levy et al., 2007). Additional uses include design, planning and operation of water infrastructure; assess water quality management options; evaluate consequences of planning decisions on e.g. runoff, biodiversity, water quality, and flood risk; analise alternative development strategies for urban agglomerations; prioritise watersheds in terms of environmental sensitivity. They are used from the local planning level up to and beyond the river catchment level. SDSS are widely recognised as an extremely powerful planning tool. Numerous international institutions foster their distribution and uptake around the world, including the World Bank,

	the Asian Development Bank, and the water-related agencies of the UN (Stakhiv and Stewart, 2010). Web technologies allow for information sharing, ubiquitous access, and cost reduction (Sugumaran et al., 2004; Dymond et al., 2004).
Costs	Due to the very different aims and scope this measure can have, it is not meaningful to provide a general evaluation of costs associated with it. The costs of such a system vary strongly depending on aim, ambition, and level of detail of system; information requirements and its sources; information processing needs; maintenance and information update requirements; etc. Regarding floods, literature on sDSS claims that these reduce downstream flood damages (Shim et al., 2002) and reduce flood management costs (Levy et al., 2007). Due to the enormous costs of damages associated with floods, it can thus be expected that the benefits of the measure in terms of social costs are one or more orders of magnitude higher than the costs. In addition, literature claims that the measure saves lives and increases decision-making effectiveness, efficiency and transparency (Levy et al., 2007).
EU Policies concerned and institutional process	This measure cannot be related to EU policies. However the development of such systems can be supported by the Framework Program for Research. The EEA might develop such a system for inhouse modeling
Character of measure	Preparatory
Sector(s) affected	Water management
Time to implement	Short term (5-25 yr)
Administration level	All levels involved: National, regional, and municipality.
Reference	Dymond, R. L.; B. Regmi; V. K. Lohani; and R. Dietz (2004) Interdisciplinary Web-Enabled Spatial Decision Support System for Watershed Management. Journal of Water Resources Planning and Management. July / August, 2004. EEA (2009) Vulnerability to climate change and adaption to water scarcity in the European Union. Levy, Jason K.; Jens Hartmann; Kevin W. Li; Yunbi An; Ali Asgary (2007) Multi-Criteria decision support systems for flood hazard mitigation and emergency response in urban watersheds. Journal of the American Water Resources Association, Vol. 43, Issue 2, April 2007 Makropoulos; C. K.; Butler, D.; Maksimovic C. (2003) Fuzzy Logic Spatial Decision Support System for Urban Water Management. Journal of Water Resources Planning and Management. January / February, 2003. Shim, Kyu-Cheoul; Darrell G. Fontane; and John W. Labadie (2002)Spatial Decision Support System for Integrated River Basin Flood Control. Journal of Water Resources Planning and Management. May / June, 2002. Stakhiv, Eugene; Stewart, Bruce (2010) Needs for Climate Information in Support of Decision-Making in the Water Sector. Procedia Environmental Sciences 1 (2010), 102–119. Sugumaran, Ramanathan; James C. Meyer; Jim Davis (2004) A Web-based environmental

decision support system (WEDSS) for environmental planning and watershed management. Journal of Geographical Systems (2004), Issue 6:307–322.

DEVELOPMENT AND PLANNING BASED ON CLIMATE RISK ASSESSMENT

Measure Number	SA02
Description	The Climate Risk assessment aims to assist authorities, investors and planners in integrating the latest information on climate change impacts, possible adaptation response options, and investment selection criteria that take climate change into account
Measure category	Support Action
Measure sub-category	Risk prevention
Climate threat	Not enough water (scarcity & droughts), Too much water (flooding, sea level rise, coastal erosion, Deteriorating water quality & biodiversity
Link to vulnerability	This measure adresses all impact indicators via pressure indicator management practices. It influences land use (pressure), management practices (pressure); resource use (Pressure) as well as the drivers preferences (sensitivity) and mitigation (exposure.
Expert and stakeholder judgement	Considering Adaptation behaviour and construction in flood prone area, which was assessed to have high urgency. For adaptation of the design factor for flood protection stakeholders assigned a high priority and urgency for the measure, and a high importance at the EU level. Overall the measure aimed to include climate change into the strategic environmental assessment showed a medium performance as compared to the others. The measure was judged as being of relatively high interest by the group of experts from north and south Europe, while the experts from western and eastern Europe considered this measure as being of lower relevance. Overall the criterion considered as having the best performance is robustness and the lowest was related to institutional requirements. Subjected to a fast track assessment, the stakeholders assigned a high priority and urgency for the water assessment for new spatial development, and a high importance at the EU level. Furthermore to adapt waste water treatment and sediment to more frequent extreme situations' has been ranked higher by experts coming from southern Europe, probably because of the more extreme climate events with flash floods and storm rainfall. There is however a high uncertainty in climate projections and needs to be flexible, e.g. assume a certain degree of change. It is considered as a cost efficient measure of no-regret measure with few negative effects. It is relatively cheap compared to sewers treatment investment. Complementary measures are catchment management in watershed and more separate sewerage systems for stormwaters in urban area. So not applicable to all countries of EU as in many countries sewerage and storm water are separated but most relevant in urban areas dense in future anticipating infrastructural change like in industrial sector already.
Qualitative assessment based on literature review	Climate Risk assessment can be implemented in various aspects of development and planning. The best strategy to climate proof future **development** is to avoid flood prone areas or areas exposed to coastal erosion. However, many existing settlements are already present and, for various socio-economic reasons, new developments are being still planned in flood prone areas. With the projected increased risk of flooding in many parts of Europe, combinations of structural and non-structural measures to climate proof existing and new

developments and change the behaviour of those living in flood prone areas are needed to reduce the risks (Kreibich et al., 2005; Andjelkovic 2001). Various precautionary measures can be taken to reduce losses in flood prone areas. These are generally subdivided in two categories: structural and non-structural measures.

Structural measures primarily aim to modify flooding or provided protection against flooding, such as dams, storage reservoirs, dikes, floodwalls, terps or mounds, evacuation hills, and flood diversion, channels. However, with the growing understanding that risks have increased in the last decades, innovatory combinations with non-structural measures have become more common practice.

A common structural measure is to improve the flood defence infrastructure. Even though it is impossible to design a fail-safe flood defence infrastructure, it is crucial to reduce the likelihood of floods and/or the impact of floods (Kundzewicz 1999). In the past, the 100-year flood event has been commonly used to develop flood scenarios. The Floods Directive (2007/60/EC) demands the production of hazard maps with scenarios of a low probability with even more severe criteria. According to the directive, the preliminary flood risk assessments will also take the impacts of climate change on the occurrence of floods into account. Consequently, new guidance values for flood assessment are developed.

However, adapting constructions in flood prone areas alone will be insufficient. Therefore, non-structural measures play an important role to adopt to climate change. **Non-structural measures** include preparedness, response, legislature, financing, environmental impact assessment, reconstruction and rehabilitation planning (Andjelkovic 2001).

In order to integrate these measures in new and existing developments in the areas at risk of climate change, **spatial planning** approaches have been used, especially when a holistic risk-based approach is taken. Spatial planning is not only useful in developing flood risk management plans, searching for opportunities, synergies and trade-offs between domains, but also to facilitate communication between stakeholders, enhance participation and reduce conflicts (Biesbroek et al. 2009; Neuvel & van der Knaap 2010; Wilson 2006). One of the key instruments, which are often used in this process are (interactive) flood risk maps to identify and communicate the risks of flood prone areas to stakeholders (de Bruijn and Klijn 2009). However, flood risks and their impacts are not yet mapped for all flood prone areas in Europe (de Moel et al. 2009).

Since the prospect theory, developed by Kahneman & Tversky (1979) allows one to describe how people make choices between alternatives it is well known that the most serious risks are often underestimated. Risk based assessments are a promissing aproach to overcome this obstacle, especially, when important and long-term planning desicions in the context of climate change adoption have to be taken. For instance in the field of flood defense, risk assesments are used for preparing hazard maps and to establish an improved flood disaster mitigation system (e.g. Plate 2002, Bower et al. 2010). Through this process, structural and non-structural alternatives can be evaluated an implemented into planning decisions. The advantage of this **risk-based approach** is that it can describe cumulative impacts from various pressures at the same time. As far as long-term planning is concern, the recognition of cummulative risks ist crucial. The measure is deemed to implement in areas that are facing multiple hazards.

Another approach for effective climate change proofing at the planning and programming level is the **Strategic Environmental Assessment (SEA)**. Foreseeable negative impacts from climate change can be reduced or even prevented by integrating climate-proofing procedures into this decision-making process. The measure addresses authorities and planners to assessing the cumulative climate-related impacts of their policies, plans and Programs (PPPs). Since the SEA emphasizes not only environmental but also socio-economic conditions, it shows cross-sectoral benefits. These benefits are made especially clear when

	applied to areas with high vulnerability concerning adaptation to climate change. Consequently, implementation is crucial. The earlier climate change aspects are addressed in the planning hierarchy, the better. Nevertheless, this measure can also be applied on later stages, for instance in context with detailed spatial (development) planning. Based on an extensive literature review, Posas (2011) concludes that the EU SEA Directive-based climate change criteria holds significant promise and potential to “design meaningful climate-related interventions, and promote more environmentally sustainable PPPs overall.” Helbronn et al. (2011) points out, by using regional plans as an example that the SEA cannot guarantee appropriate planning decisions, but can make region’s potentials for climate adaptation and mitigation transparent. Even so, climate indicators and proofing tools within the SEA are still a subject of research (Helbronn et al. 2011). Some suitable guidelines have already been introduced (e.g. Environment Agency 2007). Further research consideration should be paid to: (i) explicit minimum standards, (ii) practical approaches to derive planning objectives and (iii) standardized climate proofing indicators (Posas 2011). Compared to other planning measures, experts expect the mandatory climate change criteria within SEA to have a fair potential to respond to actual and future climate changes. One reason for this is because even secondary and cumulative effects are to be considered. The measure shows a positive benefit-cost ratio, since the goals of climate adoption and mitigation are mainstreamed as a cross-cutting responsibility in all PPPs. At the same time investment costs are relatively low. Non-structural measures can also be promoted by economic instruments. For instance the assessment framework for water utilities aims to **assist asset planners** in integrating the latest information on climate change impacts, possible adaptation response options, and investment selection criteria that take climate change into account. In the water industry, an Asset Management Plan (AMP) is a tactical plan for managing an organization’s infrastructure and the availability of natural resources. Typically, an AMP is focused on potential improvements to the Standard of Service, but the assessment of environmental benefits has become more and more important. The measure aims to assist asset planners in incorporating the latest information on climate change impacts, possible adaptation response options, and investment selection criteria that can take climate change into account. Consequently, the WaterUK assessment framework provides valuable for the AMP process in terms of: • Climate Change Impacts: input at the “Collect Asset Data” + “Needs Definition” stages of the planning process. • Adaptation Response Options: input at the “Option Development” and “Investment Selection” stages of the planning process. Companies can use this tool it as a reference to highlight issues in order to come forward with the most adequate and cost effective adaptation strategy.
EU Policies concerned and institutional process	Water Framework Directive (WFD), EU Flood Risk Management Directive, WS&D-policy, Birds Directive, Habitat Directive, EU Waste Framework Directive, Council Reg (EC) N° 1083/2006, Eurocodes, EIA Directive, SEA Directive
Character of measure	Preventing/Preparatory/Reactive

Sector(s) affected	All sectors directly or indirectly affected
Time to implement	Short term (5-25 yr) and mid- to long term (25+ yr)
Administration level	National, regional, local
Examples	**Structural Measures** Many measures already exist to adapt to climate change. Tompkins et al., (2009) for example identified over 300 measures in the United Kingdom in 2005 and de Bruin et al., (2009) identified almost one hundred different measures in the Netherlands. In addition, several databases exist where measures are collected (including the ABI and FEMA). More specific measures for flood prone areas have been identified for example dams, storage reservoirs, dikes, floodwalls, and flood diversion, and channels. Other non-structural measures include early warning systems, flood forecasting systems, preparedness and response assessments, hard and soft forms of legislature, financing schemes, environmental impact assessment, reconstruction and rehabilitation planning (Kreibich et al., 2005; Andjelkovic, 2001). **Non-structural Measures** The use of existing legislation to discourage development in inappropriate locations, e.g. , and to relocate assets from at-risk areas.For instance in the last years, there have been a number of proposals drafted on how to integrate climate change considerations into the seven main procedural stages of the SEA (e.g. OECD 2009, Environment Agency et al. 2007).
Case studies	**Structural Measures** Many case studies exist where flood risk policies and practices have been documented, particularly for local areas; see for example the UK Climate Impacts website. **Non-structural Measures** A strategic assessment framework for water utilities is provided by Water UK (2007) free of charge. It proposes a set of consistent adaptation response options that can feed into existing asset management planning procedures (price review, asset management). It helps to identify type and severity of impact; and come forward with the most adequate and cost effective adaptation strategy. The assessment framework assists asset planners in incorporating the latest information on climate change (impacts, adaptation, investment selection criteria). Increasingly, Environmental Assessments consider climate change issues. Many implementation examples are known from the UK and Germany (e.g. KLIMAMORO-Project). A number of North East organisations have formed the NE Climate Change partnership to take forward a case study to better understand the climate changes (threats, impacts, adaptation) (ClimateNE 2009).
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Related to REFRESH-Measure	M257/M258/M324

Disaster risk reduction – emergency management

Measure Number	SA03
Description	Emergency management comprises all activities to protect human life, property, cultural heritage and environment during hazard strikes, typically involving emergency response teams and facilities, and coordination mechanisms laid down in emergency plans.
Measure category	Support action
Measure sub-category	Risk prevention
Climate threat	Not enough water (scarcity & droughts), Too much water (flooding, sea level rise, coastal erosion), Deteriorating water quality & biodiversity, Snow
Link to vulnerability	Addresses the impact indicators Risk of (damages/losses) extreme events) via sensitivity state indicator Preparedness, Pressure indicator Management practices.
Expert and stakeholder judgement	Taking into consideration the disaster risk reduction and the emergency management, the stakeholders gave high value to the possible acquisition of temporary flood control structures and to the practices aimed to the evacuation preparation. High value was given to the measures aimed to improve the industrial risk management, but with some perplexities about the implementation. Highly debated have been the possible negative side effects and the institutional requirements linked to the implementation of this strategy. Stakeholders highly appreciated the strategies inspired by prevention, such as: emergency preparedness planning and emergency response systems in extreme risk catchments. These measures have been considered a priority and relevant at the EU policy level. Some perplexities have been pointed out about the possibility of implementation of a whole-life-cost risk methodology. Stakeholders gave high value to the strategies aimed to the possible reallocation of houses and infrastructures, highlighting the not easy implementation. The reallocation of existing infrastructures has been considered extremely costly and hardly feasible, but the introduction of this strategy into the urban planning activity has been highly appreciated. The strategies aimed to the disaster contingency planning and to the business continuity plans to prepare for natural disasters are considered tangible and risk free solutions. The establishment of a risk-based State policy has been highly considered, pointed to the high benefits even in case of less pronounced climate change impacts.
Qualitative assessment based on literature review	The disaster risk management is typically organised along five stages including prevention, protection, preparedness, response, recovery and review. Territorial and urban planning, as well as land management, play an important role in risk prevention, by limiting the development in flood prone areas, and by encouraging flood and drought risk-sensitive land use and management practices. Water management's central role in disaster risk management entails identification of areas prone to natural hazard of different intensity and frequency, and implementation of protection measures, both structural and non-structural, aimed to reduce the exposure and/or vulnerability to strikes of 'capricious nature'. Emergency management (EM) is part of the preparedness and response stages and is typically managed by civil protection (CP) services. CP attends to the residual risk, that is risk that persists after adopting all cost efficient and/or collectively decided risk

	prevention/protection measures. Up-to-date early warning systems and well-thought emergency plans are key instruments for further curtailing the residual risk. EM is pertinent to all climate-related risks including slow-onset (drought) and rapid-onset (flood) disasters. Up-to-date early warning systems (addressed in a different factsheet) and well-thought emergency plans are key instruments for further curtailing the residual risk. The emergency plans contain specification of the roles and coordination between various actors, specification of the shelter places for the evacuated population, emergency equipment and facilities, disaster contingency plans etc. It is a best practice to develop emergency plans at all administrative levels (from municipal up to the national level) with different level of detail and partly content. The emergency operations focus primarily on the protection of human live and limiting the impact of disasters. Part of the emergency operations can be deployment of temporary flood control structures, water tanks or bottled water distribution, and mobile water purifiers and sanitation. Emergency responses may also include water restrictions and rationing that are handled in a different factsheet. During the 2008 droughts in Cyprus and Spain (Barcelona) the emergency responses also included the shipping of water from Turkey and France respectively. During the crises, ordinary regulations are or may be superimposed by emergency norms and regulation. For example, during the 2003 drought that affected large parts of Europe the regulations limiting the abstraction of water for nuclear or thermoelectric power plants in cases of low river flow and water temperature exceeding given thresholds were temporarily modified or put on hold in order to prevent larger systemic failures. More commonly, the environmental flow regulations are violated during the water crises in order to guarantee sufficient water for basic human needs.
Costs	It is a widely held belief that the risk prevention is less costly and more efficient than the
EU Policies concerned and institutional process	EU Community Civil Protection Mechanism, Flood Directive, WS&D policy In Europe, the civil protection is the responsibility of the Member States. The Community Civil Protection Mechanism (CCPM) was first established in 2001 (Council Decision of 23 October 2001) and modified/extended in 2007 by the European Council's Decision 2007/779/EC, Euratom. More recently, the European Union's efforts in disaster risk reduction intensified with the EC Communication on Disaster Response Capacity (EC 2008). This Communication highlighted the need for stepping up the Community capacity and effectiveness to respond to disasters, within and outside the EU. To do so, the EC proposed several tangible means for a better coordination of various EU/Community policies, instruments, services and players (at national, European and international levels). While the Communication focuses on the response to disasters, it acknowledges that a comprehensive approach to disaster management is needed comprising risk assessment, forecast, prevention, preparedness and mitigation. As a follow-up, the EC released two additional Communications in 2009. The first, COM(2009)84 (EC 2009a), sets to scale up the support for disaster preparedness capacities in third countries facing high levels of risk. In this Communication, among others, the EU commits itself to help to expand research (including on social science) capacity and training in developing countries. The second, COM(2009)82 (EC 2009b) stresses the need to make research results easily and systematically available for DRR practitioners, and to develop a database for experts with specialist knowledge. In the flood risk domain, the Directive 2007/60/EC on the Assessment and Management of Flood Risks (hereafter Floods Directive) was adopted on 18 September and entered into force on 26 November 2007. The adoption of the Directive concludes the legislative efforts not at least triggered by devastating floods along the Danube and Elbe rivers in summer 2002.

	To be effective, the flood risk management has to ensure that the provisions of Floods Directive (and the legislation which transpose it into Member State's normative framework) and Civil Protection Mechanism are closely integrated, both horizontally - and vertically. In 2011, the European Council recognised 'the need for Member States and the EU to take an integrated approach to flood management, building upon existing Member State and EU legislation and policies, with special attention paid to the Floods Directive, encompassing the entire disaster management cycle (prevention, preparedness, response and recovery) (European Council 2011). The Floods Directive focuses primarily on prevention, protection and preparedness, whereas the CCPM addresses issues relevant for preparedness, response and to some extent recovery. Prevention includes non-structural activities reducing the flood impacts such as restricting the development of flood plains; risk-proofing of buildings and infrastructure; and flood-sensitive land use, agricultural and forestry management practices. Protection addresses both structural and non-structural measures reducing the likelihood and/or impacts of flood such as flood defences work, temporary flood storage areas etc. Preparedness includes recognition of the imminent danger (i.e. early warning system) and communication of risk. Response entails all emergency activities aimed at protecting human life, property, environment, and cultural heritage. Recovery and review (lessons learned) address activities in the aftermath of the emergency helping to restore normal/ordinary conditions and to help to bear the inflicted hardship.
Character of measure	Preventing/Preparatory/Reactive/
Sector(s) affected	Water management, Agriculture, Energy, Industry, Forestry, Navigation, Domestic /Tourism
Time to implement	Short term (5-25 yr)
Administration level	National, Regional or RB, Municipality/company
Examples	Industrial accidents leading to pollution of water bodies can have strong impacts on ecosystems already under additional stress due to climate change impacts. Finland has addressed this risk by increasing industrial security. In addition to environmental benefits, the measure has clear additional benefits for human health.
Case studies	The UK's Environment Agency is currently compiling a register of catchments where the potential speed, depth and velocity of flooding could cause extreme risk to life. Once this register has been completed, a review will be carried out on policy, processes and flood awareness information in these high-risk areas. Emergency response in these catchments will also be reviewed.
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INFORMATION AND KNOWLEDGE MANAGEMENT

Measure number	SA04
Description	Strategic monitoring on specific indicators and reporting activities provide baseline information that may indicate the inception of impacts. Early warning systems help decision makers and private individuals at all levels to reduce the impacts on extreme climate events. The information should be reliable and timely available with a strong focus on the people exposed to risk, in order to increase resource use efficiency. Information can be obtained from improved flood predictions, weather forecasts, the state of waters and aquatic ecosystems in a region, by weather radar and satellites observations and collected and shared through related networks.
Measure category	Support Action
Measure sub-category	Awareness/ Information
Climate threat	Not enough water (scarcity & droughts). Too much water (flooding, sea level rise, coastal erosion) Deteriorating water quality & biodiversity and snow
Link to vulnerability	The measure reduces the impact of extreme climate events on people and assets affected, by decreasing the sensitivity state (preparedness) through monitoring, networking and the improved prediction of extreme events. Timely warning could result in a change in resource use efficiency.
Expert and stakeholder judgement	Drought monitoring and improved flood predictions have a high urgency and high EU priority as are the rehabilitation of early warning systems in Southern Europe. A network for ecosystems is not identified as being of EU relevancy.
Qualitative assessment based on literature review	Global climate change will increase the probability of extreme weather events, which may be associated either with high precipitation (i.e., storms, floods, and landslides) or with low precipitation (i.e., heat, drought, wildfire). These events often overwhelm the capacity of communities and local governments to respond, requiring outside assistance.(Keim 2008) At present the analysis and preparation of information are particularly critical points of an early warning chain. The responsible decision makers are usually confronted with huge amounts of structured and unstructured data. To enable reliable early warning, the available data must be pre-selected, analysed and prepared. The decision makers should be provided with a reliable and manageable amount of information for the warning decision and for taking preventive measures. (Breunig, Reinhardt et al. 2007) Early warning systems for natural hazards need to have not only a sound scientific and technical basis, but also a strong focus on the people exposed to risk, and with a systems approach that incorporates all of the relevant factors in that risk, whether arising from the natural hazards or social vulnerabilities, and from short-term or long-term processes (Basher 2006) To be effective and complete, an early warning system needs to comprise four interacting elements namely: (i) risk knowledge, (ii) monitoring and warning service, (iii) dissemination and communication and (iv) response capability. While this set of four elements appears to

have a logical sequence, in fact each element has direct two-way linkages and interactions with each of the other elements. (Basher 2006)

Enhanced ability to forecast peak discharges remains the most relevant nonstructural measure for flood protection. Extended forecasting lead times are desirable as they facilitate mitigating action and response in case of extreme discharges(Reggiani and Weerts 2008).

The incorporation of numerical weather predictions (NWP) into a flood warning system can increase forecast lead times from a few hours to a few days. The current NWPs fall short of representing the spatial variability of precipitation on a comparatively small catchment. This perhaps indicates the need to improve NWPs resolution and/or disaggregation techniques to narrow down the spatial gap between meteorology and hydrology (He, Wetterhall et al. 2009). Moreover, there is the need both for more theoretical development of flood forecasting systems and a convincing all encompassing strategy for tackling the cascading of uncertainties in an operational framework. Currently, hydrological and hydraulic forecasts based on NWP EPS do not lead to proper probability distributions of any forecast variable(Cloke and Pappenberger 2009).

From a first point a view the state of many aquatic ecosystems in Europe might look quite static, because the water management is optimized for many different water user requirements. However, when results from long-term ecological monitoring programs are compared (see, for example EU projects, Euro-limpacs (http://www.eurolimpacs.ucl.ac.uk) and REFRESH (Nõges et al. 2010), often the surprising conclusion is that in many cases the water system is highly dynamic and being far from a static situation. Monitoring of ecosystems is therefore not only important to observe changes and trends in a certain time frame on a particular location but also to formulate water management objectives that take into account climate induced physical/ecological interannual variability. Interannual variability in aquatic ecosystems is for example higher in a Mediterranean climate compared to a temperate North European climate.

Another important function of long-term ecological monitoring is early warning. This concerns early warning in relation to the probability of abrupt changes. E.g. foreseeing tipping points (Scheffer 2010) in aquatic ecosystems when ecological thresholds are met due to climate change such as temperature rise (Scheffer et al. 2001; Scheffer et al. 2003; Folke et al. 2004) or salt water intrusion due to sea level rise. Many of these climate change induced thresholds, are difficult to identify in highly modified water systems, but they are not negligible. This is also difficult because, in addition, global change impacts interact with each other and with local- and regional-scale changes in complex multidimensional patterns. Global networks of local and regional ecological monitoring programs might provide a relevant knowledge base that may to find spatial correlations between catastrophic shifts in ecosystems in different regions in relation to climate change (Dakos et al. 2010). An multi-disciplinary way of monitoring is required because of the many interactions and feedbacks between the physical, biotic and human components of the studied system in question.

It is difficult to develop multi-disciplinary long-term monitoring networks because responsibilities are divided over different authorities, research budgets and knowledge institutes. It is also worthwhile to mention that a significant proportion of ecological monitoring networks are maintained by NGOs, often just one ecological target group is studied, such as birds or butterflies. Parallel to the scientific observational networks many networks exist that do ecological observation on a voluntary base (van Vliet et al. 2003)

TIGGE data has been used as meteorological input to the European Flood Alert System (EFAS) for a case study of a flood event in Romania in October 2007. Results illustrate that

	awareness for this case of flooding could have been raised as early as 8 days before the event and how the subsequent forecasts provide increasing insight into the range of possible flood conditions (Pappenberger, Bartholmes et al. 2008). Developing an early warning system that responses to drought will require more research, as the onset of the disaster impact of a drought can be insidious (Keim 2008).
EU Policies concerned and institutional process	Strategically monitoring systems on natural CC impacts could be set up under WISE, the adaptation Clearinghouse and could be fed by data from GMES and national information sources either reported under the WFD or reported under the *Reporting Directive* (Council *Directive* 91/692/EEC). Such as system would produce harmonised reliable information ready for further policy making. EU Flood Directive addresses in their Flood Risk Management Plans also early warning systems. There is already a European Floods Alert System (EFAS) which is an early flood warning system complimentary to national and regional systems. It provides the national institutes and the EC with information on possible river flooding to occur within the next 3 or more days. See http://floods.jrc.ec.europa.eu/ A network for monitoring ecosystems is important to evaluate the performance of policy measures that are part of Natura 2000, the EU Habitat directive and the Water Framework Directive in view of climate change. The same holds true for other international Conventions such as the Convention for Biodiversity and the RAMSAR Convention. Additionally, this measure can be implemented through Direct payments and Rural Development Regulation.
Character of measure	Preparatory and prevention
Sector(s) affected	Water Management, Agriculture.
Time to implement	Short term (5-25 yr), mid-long term (25+yr)
Administration level	National, Regional or River basin, Municipality/company.
Examples	JRC is developing the prototype of a European Drought Observatory (EDO) to monitor, assess and forecast drought events across Europe. The observatory will monitor a number of indicators, related to different parts of the water cycle: precipitation, soil moisture, stream flow and groundwater. EDO will provide up to-date drought relevant information (e.g. monthly Standardized Precipitation Index (SPI), daily updated modelled soil moisture anomalies, remote sensing observations on the state of the vegetation cover, etc.) (Vogt et al., 2011) Examples of early warning systems can be especially found outside Europe, where (disastrous) natural climate hazards occur more often. In Indonesia, five years after the 2004 tsunami, a lot has been achieved to make the communities better prepared. (Spahn, Hoppe et al. 2010). In Europe there are several global ensemble weather prediction systems through the ''THORPEX Interactive Grand Global Ensemble'' (TIGGE) archive provides an opportunity to explore new dimensions in early flood forecasting and warning. TIGGE data has been used as meteorological input to the European Flood Alert System (EFAS) for a case study of a flood event in Romania in October 2007.
Case studies	Finland's National Strategy for Adaptation to Climate Change outlines recent trends in

European and Finnish flooding and detail which parts of Finland will be most vulnerable, what the effects may be (sectors, infrastructure, human lives, etc), and what adaptive measures can be taken.

The Napa County Resource Conservation District carries out extensive monitoring of their watershed quality, including general indicators such as rainfall, water quality, and stream flow, biological indicators such as fish populations, gravel permeability, and water temperature, and hydrological monitoring such as stream flow monitoring and channel width.

The Global Monitoring for Environment and Security (GMES) services are dedicated to the monitoring and forecasting of the Earth's subsystems and contribute to the monitoring of climate change. GMES services also address emergency response (e.g. in case of natural disaster, technological accidents or humanitarian crises) and security-related issues (e.g. maritime surveillance, border control).

An example of ongoing research and implementation of improved flood predictions is the development of the European Flood Alert System (EFAS). It is developed to increase the preparedness for floods in trans-national European river basins. It provides local water authorities with medium range and probabilistic flood forecasting information 3 to 10 days in advance. Flood warning lead-times of 3–10 days are achieved through the incorporation of medium-range weather forecasts from the German Weather Service (DWD) and the European Centre for Medium-Range Weather Forecasts (ECMWF), comprising a full set of 51 probabilistic forecasts from the Ensemble Prediction System (EPS) provided by ECMWF(Thielen, Bartholmes et al. 2009)

Another study researches flash floods in Mediterranean Europe. The study investigates if operationally available short range numerical weather forecasts together with a rainfall-runoff model can be used as early indication for the occurrence of flash floods(Younis, Anquetin et al. 2008)

One of few examples of a long-term multidisciplinary ecological monitoring network is TAIB Project S'Albufera (Riddiford 2008). This is an intensive study of a coastal wetland and sand-dune complex in Mallorca, originally designed by Earthwatch Europe (1991) in collaboration with the authorities of the Parc Natural de S'Albufera (Mallorca, Spain). The project aims to evaluate the effects of a controlled management regime in wetlands, regional pressures and global change. The project aims to provide scientifically based guidance for conservation management planning. This is being achieved through the constant monitoring of indicator species, and functional analysis of the ecosystem with targeted studies, for example regarding aquatic ecology (Veraart et al. 2004), often in collaboration with internationally recognized scientists and research institutes.

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Related to REFRESH Measures	M290, M186, M119, M173, M221, M417, M409, M206

AWARENESS AND CAPACITY BUILDING

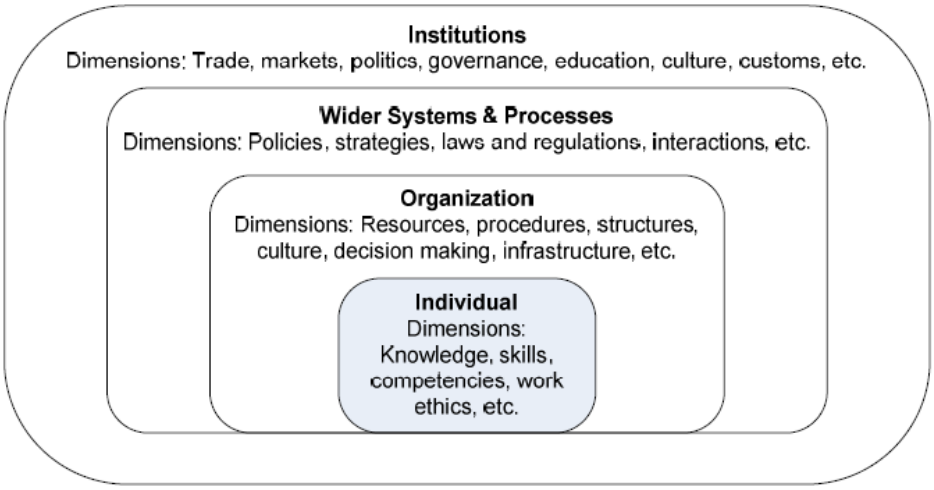
Measure Number	SA05
Description	This measure encompasses actions that promote awareness for the altered conditions under Climate Change. It strengthens the capacity of stakeholders affected by weather extremes from civil society groups, local and national governments to better address the impacts of climate change by their involvement. Awareness and capacity building can address groups of people in a region affected by a particular CC threat, groups of stakeholders, the general public, etc. The ultimate aim is to achieve behavioural changes. Actions which share information about ongoing impact assessments and adaptation activities will lead to a wider range of organizations who are thinking about climate-related problems.
Measure category	Support Action
Measure sub-category	Awareness/information
Climate threat	Not enough water (scarcity & droughts), too much water (flooding, sea level rise, coastal erosion), Deteriorating water quality & biodiversity (weaker), Snow (weaker)
Link to vulnerability	This measure reduces the impact (people and area affected) of climate events (all climate threats) by decreasing the sensitivity through improvement of awareness and better preparedness (State indicator). Furthermore, the measure directly affects management practices (pressure) and resource use efficiency (root causes) leading to changes in preferences and mitigation.
Expert and stakeholder judgment	The experts and stakeholders agreed to consider the measure as a priority especially in the most drought prone areas of Europe. They recognize that it is a necessary strategy to reduce overall sensitivity. If done properly, raising awareness and capacity building requires a long term investment (in time and resources) that starts from the beginning of the adaptation process, but is fairly easily implemented against relatively low costs. The expert and stakeholders recognize that awareness raising is more than providing information, maps or other tools. Side effects have been considered not really relevant for this measure.
Qualitative assessment based on literature review	Adaptation to climate change requires the conjoint efforts of individuals, businesses, industries, governments and other actors that are confronted by the impacts of climate change and are interdependent for achieving successful adaptation (Biesbroek et al., 2010; Tompkins and Adger, 2004). One of the key soft policy instruments in the governance of adaptation therefore is raising public and political awareness about the impacts, vulnerabilities and the need to adapt to climate change (ASC, 2010). Public awareness is important to increase enthusiasm and support, stimulate self-mobilisation and action, and mobilise local knowledge and resources. Raising political awareness is important as policy makers and politicians are key actors in the policy process of adaptation. Awareness raising requires strategies of effective communication (van Woerkum 2007) to reach the desired outcome. The aim of awareness raising and capacity building most often differs between contexts but generally includes increase concern, informing the targeted audience, creating a positive image, and attempts to change their behaviour. Awareness and capacity building

are considered to be important components in the climate change adaptation science-policy-society interface and in overcoming individual barriers to adaptation, such as skepticism, denial, and ignorance (Swim et al. 2009)

Capacity building (and capacity development) can be viewed as container concepts. Many people have tried to capture their meaning in terms of a definition. A broad but appropriate starting point seems to be the general definition produced by UNDP (1998):

Capacity development is the sum of efforts needed to nurture, enhance and utilize the skills and capabilities of people and institutions at all levels – locally, nationally, regionally and internationally - so that they can better progress towards sustainable development.

Developing capacity involves empowering people and organizations to solve their problems, rather than attempting to solve problems directly. When capacity development is successful, the result is more effective people and institutions better able to provide products and services on a sustainable basis. This definition stresses that capacity development is more than training at the individual level. It also involves strengthening capacities at the organizational level and developing enabling institutions (see figure 1).



(Adapted from FAO, 2006)

Present global changes such as climate change confront water managers and other decisions makers with new challenges. Climate change adaptation entails addressing uncertainty and complexity due the involvement of multiple stakeholders interacting with ecological, technical and financial systems at various levels (IPCC 2007). Stakeholder participation is highly valued because people are far more likely to support adaptation strategies if they feel their views have been taken into account. In addition, the IPCC regards learning as an important element of adaptation. If new knowledge, skills and attitudes are not acquired, adaptation cannot take place (Parry *et al*., 2007). As a response to the need for being able to address uncertainty and complexity, current approaches to capacity building for adaptation can be characterised by an emphasis on multiple systems (or systemic thinking), participation of stakeholders, learning and adaptive water management (e.g. Wigboldus *et al*. 2010).

Guiding principles for capacity building

At the World Climate Conference-3 (2 September, 2009) a set of guiding principles for capacity building for adaptation has been discussed (START &UNESCO 2009). Lessons from past experiences in all over the world show it is important that :

- Capacity-building should not be targeted solely at the scientific community but rather should be done in a holistic, integrated manner that builds capacity for interaction and dialogue among scientists, policy makers, and other societal decision-making groups, where the scientific community's role is to provide the science-base for a rational, constructive dialogue among stakeholders with different views.

- Capacity-building works best if it first achieves local benefits on local priorities, then addresses participation in global climate research, rather than the reverse.
- Capacity development should be country-driven: countries must determine and drive activities from conception to evaluation.
- Capacity development should be issue-based: activities should be determined by the country's societal issues to be addressed, rather than determined by a specific tool, programme or expertise.
- Relevance, ownership and sustainability are the key aspects to ensure success of capacity development activities in the medium and longer term.
- Capacity-building should occur within a framework of integrated, interdisciplinary problem solving that reaches across a broad swath of sectoral and livelihood interests, including agriculture, forestry, fisheries, water resources management, meteorology and climatology, energy, public health, disaster management, urban planning, and rural development, among others.

Pillars of capacity building and their capacity-building needs

Three main pillars of capacity-building for adaptation can be distinguished: knowledge generation, knowledge sharing & learning, and experimentation & informed action. Each pillar has unique capacity-building needs.

Knowledge generation: In many countries, constraints to climate change knowledge generation include relative scarcity of data and tools appropriate to specific (local) contexts, data gaps about important climate processes, weak data management systems and lack of appropriate regional climate models and scenarios. However, some argue that in climate change adaptation it is often not information that is missing but knowledge (Lonsdale and McEvoy**,** 2009). Ways to filter the information what is available in order to make it usable and to facilitate the transfer of information into knowledge is what is required. Country- and region/local specific assessments are needed to address this issue.

*Knowledge exchange & continuous learning***:** Capacity building efforts to support knowledge exchange and learning processes should aim to strengthen communication and learning at the science-society-policy interface. It should also enhance communication and coordination between suppliers and users of "climate services". Communities of Practice involving scientists, policy makers and other societal practitioners who share a similar concern for something they do and learn how to do it better as they interact regularly can be a very useful for capacity building.

*Experimentation & informed action***:** Experimentation combined with systematic reflection provides good opportunities for learning by doing. Moreover, mobilizing decision-makers to act on information and knowledge in support of adaptation requires that they have access to relevant information from credible sources. Capacity building to promote the development of robust systems for climate risk communication is a key.

Although awarenss raising and capacity building is often considered to be important at the first stages of the adaptation process, research shows that levels of awareness fluctuate through time under the influence of external variables. For example, the Al Gore movie ‘An Inconvenient truth’ (2006) and IPCC Nobel Peace Prize has a positive effect on the public awareness whilst the 2011/2010 cold winters in Europe, the minor IPCC errors and CRU (Climate Research Unit) emails have negatively influenced public acceptance of climate change and increased public sceptisism (Leiserowitz et al. 2010). Therefore, raising awareness is not only important at the first stages of the process but is integral throughout the process to maintain and increase the general level of awareness.

Awareness raising is a complex task with results hard to predict (ADAM 2011). Although it is very difficult to measure the effectiveness of awareness raising as there are few outcome indicators, frequently conducted qualitative and quantitative surveys can provide valuable insights. A recent 2011 survey among individuals of 12 EU countries showed that on average 49% felt informed about the causes of climate change (n=13091) which is 6% less than the same survey in 2009 illustrated, driven by an increase in the number of people who claimed to feel ''not at all informed'' (from 9% to 15%). Less than half of the respondents (46%) felt informed about the ways to deal with climate change (including adaptation) which is 5% less than the same survey in 2009. The report concludes that ‘in general, one can observe a decrease in the level of self-perceived awareness about climate change among respondents of the 12 Member States surveyed.’ (Eurobarometer 2011)

Large climate change awareness raising campaigns are often a mixture of mitigation, energy efficiency, and sustainability measures rather than adaptation measures. For example, the campaign ‘You Control Climate Change ‘ (2006-) of the European Commission aims to inform individuals about climate change, initiate pro-active dialogues, and aims for (small) behavioural changes without affecting individuals’ every day lifes by giving them a sense of empowerment and personal responsibility (CEC 2011). The targeted audience are particularly those individuals that are ‘sometimes active’ in environmental issues (42% of the EU citizens). The Commissions strategy has been to adress the skeptisism of this targeted group by reducing there skepticism and convince them that individual actions are worthwhile and can lead to big contributions to reduce climate change. To reach this goal the EU heavily invested in tools such as as advertising, website, exhibitions, media relations, events, and schools programmes at both European and national levels. In addition, the EU financed national awarenss campaigns in its Member States. In 2008, the EU payed addition efforts to Hungary, Poland, the Czech Republic, Romania and Bulgaria, where national awareness campaigns have not yet been implemented.

The Raising Awareness on Climate Change and Energy Savings (RACES) project aims to raise awareness on climate change impacts in the urban environments in Italy, targeting school teachers, families and local stakeholders (RACES 2011). The project aims to measure the effects of the campaign on the climate proofing of the urban environment of Florence, Trento, Modena, Potenza, Bari as case studies. Several comunication tools are used, including free lessons, exercises and essays for teachers, seminars, workshops and information packages.

In the Netherlands, the Living with Water campaign (2003) focussed on increasing public awareness about the risks of water, inform citizens about what they should do in case of flooding, and inform citizens about the new policy approach for water management (room for the river). The government used televisions, radio and newspaper/magazines as modalities to communicate their messages using a well-respected weather reporter as their spokesman. The results of the campaign were deemed very successful; recommendations were made to commence regional awareness raising campaigns (VenW 2004).

In the Netherlands, the campaign ‘living with water’ showed an increase of public

	awareness where up to 82% of the population recognized the social importance of measures to protect against flooding and 72% of the respondents agreed to the proposition that this would have to involve 'giving room to the water' (VenW 2004).
EU Policies concerned and institutional process	European Climate Change Program (ECCP) and the White Paper on climate change adaptation, Water Framework Directive, Floods Directive, Water Scarcity and Droughts Policy. All third generation EU policy frameworks as well as the implementation of EU regulations require the involvement of stakeholders at the local, regional and national level (e.g. Water Framework Directive & Flood Directives). The program of measure required under the WFD contains several stakeholder capacity building mechanisms. In particular, the measure 'building stakeholders' capacity' could be promoted by: the European Climate Change Program (ECCP) and the White Paper on climate change adaptation. *European Climate Change Program (ECCP):* The ECCP forms the broader framework through which the EU can support and complement efforts of the Members States in the field of (capacity building for) adaptation. For example, the EU can support capacity building for adaptation by promoting greater coordination and information sharing between Member States (e.g. Clearinghouse Mechanism for Adaptation) *White Paper on climate change adaptation*: In April 2009 the European Commission presented a policy paper known as a White Paper which presents the framework for adaptation measures and policies to reduce the European Union's vulnerability to the impacts of climate change. The proposed framework focuses amongst others on 'building a stronger knowledge base since sound data is vital in the development of climate policy' which has high relevance for capacity building
Character of measure	Preventing, Preparatory, Reactive, Recovery
Sector(s) affected	Non-sector specific; includes Water management, Agriculture, Energy, Industry, Forestry, Navigation, Domestic / Tourism
Time to implement	Short term (5-25 yr), mid- to long term (25+ yr) Time for implementation and results depends on the specific themes foreseen.
Administration level	National, Regional or River basin, Municipality/company
Examples	Awareness raising addresses the knowledge concerning altered climate conditions and extreme events. Awareness campaigns can lead to water saving through more efficient water consumption and can address flood risks. It aims to ensure that all relevant regional and sub-regional bodies understand the impacts of, and take action to respond to increasing flood or drought risk. It takes on a variety of forms: dissemination of printed materials risks and prevention; organisation of public meetings and training; professional consultation on prevention; communication through mass-media; using informal networks for information dissemination. It can be combined with the establishment of community self-protection teams that promote self-reliance among residents and businesses to minimize the risk to personal safety and property damage during a flood event. An effective public communication system is essential for managing crisis situations involving threats to the public. This communication system should be able to influence a specific, mass audience swiftly and effectively.

Case Studies

Well documented case studies on capacity building for adaptation in European countries are rare. Capacity building for adaptation appears to be more common in developing countries or at least these experiences are better documented (e.g. USAID's capacity building programs; UNEP; UNDP, 2009; WWF; Terwisscha van Scheltinga and van Geene, 2010).

1. CHAMP – Local Climate Change Response
   (http://www.localmanagement.eu/index.php/champ:home?language=en)

The CHAMP is now in its third and last year and is working in the partner countries Finland, Germany, Hungary and Italy. The objective is to train and support local and sub regional authorities in implementing an integrated management system for climate change mitigation and adaptation, and to promote the model European-wide.

Within the project, national training hubs were established to conduct an Integrated Management System (IMS) trainings for local authorities. The piloting local authorities have received IMS trainings. Trainings are over in Finland and Italy and are currently taking place in Hungary and Germany. An important part of the project is the Capacity Development Package that supports local authorities in implementing the IMS for climate change mitigation and adaptation. Through a step wise approach, local authorities conduct a baseline review, set adaption (and mitigation) targets, establish political commitment, implement, monitor and evaluate the actions.

The Capacity Development Package aims to provide hands-on guidance, good practice examples and tools to establish an integrated management system and respond to the challenges of climate change adequately.

2. Capacity building and knowledge transfer in the NEWATER project (*Rotter et al., 2009;* http://www.newater.info/

Acknowledging climate change and its impact on hydrological resources is a transition from currently prevailing regimes of river basin water management into more adaptive regimes in the future. One of the objectives of the NEWATER project was to develop a holistic set of training courses including training material to support the dissemination of knowledge, concepts and tools necessary for the successful implementation of adaptive water management (for an overview of courses and training material see www.wise-rtd.info/ and for the academic curriculum www.newatereducation.nl).

The resulting training courses were held in seven NeWater case study regions to support the on going process towards adaptive water management in these basins.

3. Ontario, Canada and the US state of Delaware have launched awareness campaigns regarding agricultural and fishery best management practices that include tie-ins to climate change. The South West Climate Change Action Plan contains full details of the activities required to support the region in adapting to and mitigating the impacts of climate change, as well as a summary of the context and evidence behind the actions. Each plan included documents disseminated through websites. Awareness campaigns have been successful at improving or inciting adaptive behavior in the past, for example, when an awareness campaign motivated the replacement of oil heating facilities with electric or solar-powered ones in Bavaria. Finally, the ESPACE project promotes awareness of the importance of adapting to climate change and recommends ways to incorporate adaptation within spatial planning mechanisms at local, regional, national and European levels.

4. Organizations often hold workshops to strengthen stakeholder capacity on adaptation climate change issues. For example, in February the WWF help a workshop to build national stakeholder capacity on 'Issue identification and stakeholder engagement strategy for

	climate change adaptation' with twenty participants from Bhutan and Nepal (WWF representatives, government officials, NGOs, corporations, etc.). The Institute for European Environmental Policy (IEEP) also facilitates regular training and capacity building on climate change with a broad range of decision makers. 5. he North East England Climate Change Adaptation Study identifies 'Gathering and sharing information on climate change trends, impacts assessments and adaptation activities across the region' as one of their adaptation approaches. They note that sharing information about ongoing impacts assessments and adaptation activities will lead to a wider range of organizations thinking about climate-related problems, and solutions to them, in a different way. This should enable opportunities for collaborative approaches to be identified, which can be more effective than individual approaches and will lead to dissemination and wider uptake of best practice across the region.
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Related to REFRESH Measure	M016/M223/M224/M225/M226/M451

WATER SENSITIVE AGRICULTURAL PRACTICES

Measure Number	M01
Description	Reduction of water demand in the agricultural sector by ways different from the irrigation techniques and efficiency.
Measure category	Measure
Measure sub-category	Changing management or practices.
Climate threat	Not enough water (scarcity & droughts), too much water (flooding, sea level rise, coastal erosion), deteriorating water quality & biodiversity.
Link to vulnerability	Adresses Water stress impact indicator via changes in sensitivity State indicator Water use and Pressure indicator Resourse use efficiency.
Expert and stakeholder judgement	Among the activities included in the water sensitive agricultural practices, the stakeholders attributed some value to the use of engineered crop varieties, but they found it not free of risk the implementation of this practice. Stakeholders recognized some value to the adaptation of planting dates and cultivation practices, but they named this strategy not really a priority for EU policy. This strategy is already implemented at farm level and it is not considered to require a strong regulation at the institutional level. The stakeholders agreed that the improvement of the agricultural land management represents a tangible and risk free solution. Moreover they pointed out the high benefits of the irrigation system data collection and delivery and of an improved agricultural water management even in case of less pronounced climate change impacts. These two strategies have been considered extremely useful in order to drive the development of more and more efficient land and irrigation management.
Qualitative assessment based on literature review	The reduction in water consumption for agriculture can be achieved in many different ways. At farm level, these options include water-saving agronomic practices such as shifting from ploughing to tilling, better terracing or planting roots deeper, crop choices and alternation, timing of cultivation, precision farming based on novel technologies (GPS, satellite measurement of soil moisture), breeding or genetically altering crops to increase their drought resistance. The benefits gained through these measures depend on a host of conditions, including the prevailing soil and climate conditions, and cannot be generalised. In addition, a number of risk management measures (e.g. insurance and income diversification) are applicable, although not directly connected to water use. Many studies demonstrated that water use efficiency can be improved through the choice of planting date and appropriate soil management (e.g. Hatfield et al., 2001). An efficient and sustainable agricultural production requires practices that maximise the efficiency in water and nutrients use (Hatfield et al. 2001, Lenssen, 2008). Musick et al. (1994) showed that under different conditions, the choice of planing data can influence the grain yield in the range of between 4 to 8 per cent per week. Traditional breeding and genetic engineering pin hopes of developing crops that are resistant to drought (Hirasawa et al. 1998; Teran & Singh 2002; Verslues et al. 2006; Beebe et al. 2008). Together with efforts to increase the solar reflectivity of leaf glossiness

	(Ridgwell et al. 2009), these approaches are promising for tackling regional climate change. Engineered and transgenic crop varieties are considered to have a large potential for reducing the water consumption in agriculture, improving flavor or nutritional quality of foods, and reducing pesticide use (Marvier, 2001). However, these techniques are not free of controversy because of the potential risk the genetically modified organisms pose to human health (e.g. production of novel allergens or carcinogens), biodiversity etc. (Serraj, 2002; Hoffman, 1990).
EU Policies concerned and institutional process	Common Agricultural Policy Common Agricultural Policy (in particular Agri-Environmental measures and support to investments), implemented through the Rural Development Plans are an effective framework to support and implement this measure.
Character of measure	Preventing/Preparatory.
Sector(s) affected	Agriculture, Forestry.
Time to implement	Short term (5-25 yr).
Administration level	Regional / River basin, municipality/company.
Examples	In europe there are several global ensemble weather prediction systems through the ''THORPEX Interactive Grand Global Ensemble'' (TIGGE) archive provides an opportunity to explore new dimensions in early flood forecasting and warning. TIGGE data has been used as meteorological input to the European Flood Alert System (EFAS) for a case study of a flood event in Romania in October 2007.
Case studies	In 2008, the Regional Office for Climate Change of the Pais Vasco laid out its action plan on climate change, which includes improved agricultural land management techniques for mitigation and adaptation (agriculture represents 5% of carbon emissions from the Pais Vasco). They outline specific measures and calculate the emissions reductions.
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Related to REFRESH-Measure	M159/M097

ADAPTATION OF DREDGING PRACTICE

Measure Number	M02
Description	The measure focuses on the adaptation of dredging practices to changes in erosion and siltation in rivers. Dredging methods or disposal options in use should be modified to ensure implementation with minimum environmental impacts.
Measure category	Measure
Measure sub-category	Change management or practices
Climate threat	Not enough water (scarcity & droughts), Too much water (flooding, sea level rise, coastal erosion), Deteriorating water quality & biodiversity
Link to vulnerability	The measure increases the navigability at large rivers which could be hindered by reduced **water discharge in rivers**, resulting more days per year with low water levels. The measure influences the **water quality** because it is expected that sediments in rivers are more polluted as an impact of climate change.
Expert and stakeholder judgement	Subjected to a fast track assessment, the stakeholders assigned a medium priority and urgency for the measure regarding dredging practices.
Qualitative assessment based on literature review	Through climate change, river discharges and water levels may change in the future. A reduction of river discharges in the summer will lead to lower water levels and lower water depth. These effects imply that the water level in the nautical channel of waterways will be reduced, leading to lower transport capacity of ships. As result of lower water level, ships cannot be fully loaded and for the same amount of freight, more ships are needed or more trips must be made. Because of this, the costs for transport of goods increase for companies in the summer months. Transfers to other transportation modes, like rail or road, raises transportation costs as well. Increased and decreased water levels, due to changes in precipitation will likely result in changes of the sedimentation processes such as bank failure, local scour, locations of accretion and erosion and sediments from agriculture. (EEA 2009, BMVBS 2009, Hawkes et al 2010) An ecological approach to deal with entering sediments from the surrounding like agriculture is the creation of buffer strips and reed beds. This option is a 'no regret' measure to intercept run-off and hence reduce the amount of sediment entering the watercourse. Also farmers are interested to keep soil and sediments, so this might allow a 'win-win' solution. As example, a buffer strip creation is conducted at a 17 km rural stretch at a waterway in Devon (at the Grand Western Canal Country Park). Another source of sediment input is the erosion of the riverbank at the waterline. Like buffer strips, 'green engineering' bank protection such as willow spilling, plant rolls and coir revetments can help to stabilise the bank and minimise erosion. If bank protection is already required, such measures can be considered as 'no regret' measures (IWAC 2009).

Where sediment has accumulated in a water body and monitoring indicates a risk to navigational safety, additional dredging might be required. As dredging can have adverse environmental impacts, local factors will need to be considered to assess whether there is a viable alternative to dredging. If no such alternative exists, steps should be taken in order to optimise timing and method of dredging and to protect water quality and ecology. Also under ecological considerations one possibility is to dredge deeper, more narrow nautical channels be used by smaller ships. In the German KLIWAS-project, among other options, an optimisation of the width of the nautical channel is also discussed. First results show that the nautical channel could be deepened on two thirds of the existing nautical channels and that with this width, shipment is still possible with low water levels. (BMVBS 2009, Söhngen 2008). Efforts can be made to ensure that dredging is implemented with minimum disruption of the environment, for example, by enhancing the accuracy of dredging. Turbidity caused by dredging, loss of material during transport from the dredged areas to placement areas and the dilution of dredged material should be reduced. Natural process can be used for placement and redistribuition of dredged material. (Laboyrie 2009, D'haene 2009, CEDA 2009, IWAC 2009).

Another approach aims to reduce impacts by ensuring that adequate ecological conditions are maintained in adjacent areas, e.g. in a parallel river arm. Applying renaturation of the river and its floodplains simultaneously to the deepening of the navigation channel would ensure that habitats and their capacity are maintained. Significant synergies with flood protection and nature protection are possible. (EEA 2009)

Sediment management must also be discussed in Conjunction with dredging. It is also expected that through climate change the pollution of the sediments will increase because of high water levels and floods. A pilot project in Hamburg shows the sediment ransportation in the harbour of Hamburg. At the moment the sediments are brought from the harbour directly into the river Elbe and partially to an area in the North Sea. The pilot project researches the consequences of different places for the disposal in the river and possibilities to clean and use the sediments on land (Glindemann 2009). In the Netherlands, 25 to 30 million m^3/year are dredged. At the moment 64 % of the dredged sediments in the Netherlands are relocated in the sea and 15 % are placed on land, i.e. clean dredge material is used on banks of waterways for flood protection and land improvements. It is also dicussed to use material for adpating dikes to higher floodings (Laboyrie 2009).

The building of buffer strips, reed beds and 'green engineering' bank protection are measures with lower environmental impact. And partly with positiv effects on biodiversity.

Considerable environmental consequences can be associated with the dredging of waterways; the main effects/impacts are inter alia its disrupting the vegetation (and thus wildlife habitats) on the river bed, displacing often strongly polluted sediments (either towards frequently unpolluted sections of the river/sea, or on land, creating the problem of environmentally correct disposal), and affecting groundwater levels. Although this measure cannot be considered good practice, there is a high probability of its being implemented due to the (current) lack of alternative options. (EEA 2009, Laboyrie 2009, DGE 2006)

The shipment sector **benefits** directly from the measure because transportation costs are kept low. Through security for the transportation, the shipment sector can be competitive against rail and road. Industrial companies receive indirect benefits through lower transportation costs and a secure transport.

Costs	All measures are expected to be cost-intensive. For the **costs** of sediment disposal on land the pilot project in Hamburg named an amount of 36 million euros per year (Glindemann 2009). Costs for the dredging activities occur on a yearly basis. Demirel (2011) analysed dredging practice in the river Rhine, including the influence of climate change. The results show a positive benefit-cost ratio. Different studies show a wide range of benefit-cost ratio (positive and negative) for dredging near ports, which takes into account secure shipping (The Tioga Group 2005, Wilson 2009, Wasmonsky 1997). In these analyses the social costs of dredging, sediment transport and the impact of climate change are not included. Social costs are another consequence of the environmental impacts of dredging. These are shown in the pollution of rivers through movement of polluted sediments and, the disturbance of wildlife and deterioration of habitats.
EU Policies concerned and institutional process	Water Framework Directive (WFD), Marine Strategy Framework Directive (MSFD), EU Waste Framework Directive, EU Flood Risk Management Directive. Aquatic sediment is not mentioned separately in the WFD, but is an integral part of the hydromorphological system. The dredging and the handling of the dredged material impacts the environment, i.e. through effects such as sedimentation and raised turbidity. These are anthropogenic activities with a possible impact on the good ecological status of water bodies. There is already an indirect influence if the generated impact is responsible for a water body not reaching the “good ecologic status/potential” or in case of endangering the “good ecological status/potential”. However, aquatic sediments could be directly integrated and mentioned in the WFD. It is of importance that assessment of sediment quality and dredged material be included in the objectives and the assessment of the WFD. Marine Strategy Framework Directive deals with the marine and coastal areas. The sediment transport could endanger the “good ecological status” and MS have to develop measures to reduce its impact.
Character of measure	Preventing/Reactive
Sector(s) affected	Navigation, Water management
Time to implement	Short term (5-25 yr)
Administration level	Regional / River basin
Reference	BMVBS (2009) Tagungsband KLIWAS: Auswirkungen des Klimawandels auf Wasserstraßen und Schifffahrt in Deutschland. German Federal Ministry of Transport, Building and Urban Development, Bonn. CEDA (2009) Dredging and the environment: moving sediments in natural systems. Delft 2009. Demirel, E. (2011) Economic Models for Inland Navigation in the Context of Climate Change. Diss. Vrije Universiteit Amsterdam. DGE (2006) Status of ecological assessment of dredging and relocation sites in Germany and The Netherlands. Koblenz.

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Related to REFRESH-Measure	M353

WATER SENSITIVE URBAN DESIGN

Measure Number	M03
Description	Water Sensitive Urban Design (WSUD) is an emerging urban development paradigm aimed to minimise hydrological impacts of urban development on environment. In practice, the WSDU integrates stormwater, groundwater water supply and wastewater management to protect existing natural features and ecological processes; maintain natural hydrologic behaviour of catchments; protect water quality of surface and ground waters; minimise demand on the reticulated water supply system; minimise wastewater discharges to the natural environment; and integrate water into the landscape to enhance visual, social, cultural and ecological values.
Measure category	Measure
Measure sub-category	Changing management or practices.
Climate threat	Not enough water (scarcity & droughts), too much water (flooding, sea level rise, coastal erosion), deteriorating water quality & biodiversity.
Link to vulnerability	The measure reduces stormwater flood risks (area and people flooded) in urban areas by decreasing state indicator (Exces) water availability; it also reduces water stress (impact) by decreasing the sensitivity (state) of water use and increasing water availability (state). In infiltration areas, the measure contributes to groundwater repletion.
Expert and stakeholder judgement	The stakeholders highlighted to value the measures included in the strategies for the water sensitive urban design. They agreed to consider rainwater and stormwater management in urban areas tangible and risk-free solution. This strategy, in particular, has been considered highly valuable and middle urgent, especially because of the low side effects and the efficiency and the effectiveness considered high. The reduction of water consumption of urban, private and public sectors, by the development of programmes to promote the efficient use of water, has been also considered highly valuable, pointed to the high benefits even in case of less pronounced climate change impacts. The strategy presents, for the experts and stakeholders, negligible side effects and high level of flexibility, robustness under uncertainty and implementability for decision makers.
Qualitative assessment based on literature review	With the widespread realisation of the significance of climate change, urban communities are increasingly seeking to ensure resilience to future uncertainties in urban water supplies. Yet change seems slow with many cities facing ongoing investment in the conventional approach. This is because transforming cities to more sustainable urban water cities, or to “Water Sensitive Cities”, requires a major overhaul of the hydro-social contract that underpins conventional approaches (Wong & Brown 2009). The hydro-social contract is the unwritten contract that exists between the public and the government that comes into existence when the individual is “no longer capable of mobilizing sufficient water for their own personal survival, and that acts as a mandate by which government ultimately takes on and executes this responsibility” (Turton & Ohlsson 1999). This hydro-social contract thus acts as the “basis for institutional development, and also determines what the public deems to be fair and legitimate practice such as the desire

for ecological sustainability, to which politicians react" (Turton & Meissner 2002).

Until now, several efforts in this direction have developed in Australia, whilst other countries lag behind. A city will be successful if it can manage its challenges and seize its opportunities in such a way that it reduces its ecological footprint while simultaneously improving its liveability and its resilience to the shocks of future climate change or population growth. The management of water in the city is critical in this process (Brown & Farrelly 2007).1

Water Sensitive Urban Design in Australia has evolved from its early association with storm water management to provide a broader framework for sustainable urban water management. It provides a common and unified method for integrating the interactions between the urban built form (including urban landscapes) and the urban water cycle (Wong 2006). There, WSUD is increasingly practiced in new urban green field development areas and urban renewal developments linked to a broader Ecologically Sustainable Development1 agenda.

WSUD gives emphasis to on-site collection, treatment and utilisation of storm water flows as part of an integrated 'treatment train' that may be applied in addition to, or in lieu of, conventional storm water and that can supplement water supply measures. The principles can be applied to all development types from the subdivision through to the allotment level. WSUD aims for an integrated approach across various scales, from individual allotments to large subdivision and major catchments ((McAuley et al. 2009)).

In practice, to apply WSUD principles means: 1) to protect natural creeks and other waterways on site; 2) to reduce potable water demand through measures such as water efficient fittings and appliances, rainwater harvesting and wastewater reuse; 3) to treat in a decentralised manner urban stormwater for reuse and/or discharge to receiving waters; 4) to match the natural water runoff regime as closely as possible; 5) to minimise wastewater generation and treating wastewater to a standard suitable for effluent reuse opportunities; 6) to integrate stormwater management into the landscape, creating multiple use corridors that maximise the visual and recreational amenity of the development; and 7) to support water utility innovations.

Key transition factors for WS cities are: (i) inter-organisational collaboration and coordination community participation; (ii) uniform regulatory framework and processes; (iii) organisational capacity; and (iv) organisational commitment (Brown & Farrelly 2007).

WSUD can be applied within "greenfield" developments and "retrofitted" into existing urban areas. On the one hand, "greenfield" development refers to urban development on a parcel of land not previously developed beyond agricultural or forestry uses. On the other, "retrofit" usually applies when WSUD approaches are implemented to replace and/or augment an existing system in an already-existing urban area.

When planning WSUD, strategies should consider the following technical aspects: (i) a water conservation plan (optimise water distribution amongst various uses, investigate potable water conservation, wastewater reuse and storm water harvesting opportunities in the Municipality; (ii) storm water quality (inc. storm water treatment measures); and (iii) integration with other elements of urban design. Institutional aspects, alternative approaches to community involvement, and ways to drive innovation are as important and should frame the whole process of WSUD implementation. Of course, there is no single solution that can be employed, but rather a multitude of strategies (McAuley & McManus 2009).

[1] Ecologically Sustainable Development in Australia can be described as going beyond the protection of the environment from the impacts of pollution, to protecting and conserving natural resources (Wong 2006)

	Some additional words should be spent to better define the rainwater and stormwater management in urban areas. Rainwater use eases pressure on the main water supply, reducing upstream energy and environmental costs. Besides, it reduces rainwater overflow which is particularly problematic in those cities where rainwater and sewage water are not separated. It is implemented through artificial infiltration and retardation, reduced impermeable area, pervious pavements and parking lots, local storages (ponds, building storages, groundwater cisterns); roof planting. It also includes increase of storage in the river system which can be achieved by development of flood plains, polders, and wetlands. Permeability taxation can enhance reconstruction of green areas in cities. By promoting infiltration, storage and trapping water in the catchments, flood peaks can be lowered. Improvement of drainage system can also enhance water storing. Increasing storage capacity at every scale, from rainwater tanks to reservoirs, could alleviate water scarcity. Surplus water can be stored in the wet season, to be used in the dry season. Stormwater, for instance, is a relatively clean source that is often not yet used for drinking water production. This source has the potential to make urban districts more self-supporting with regard to their water supply. The volume of stormwater runoff from a city is often greater than its entire combined household water use, and has the potential to provide water for irrigating parks, gardens and ovals, as well as replenishing groundwater supplies. The area of Northern Adelaide in Australia has launched a collaborative program called, 'Water Proofing Northern Adelaide' that sought to improve urban water management in three cities. They achieved the integration of urban stormwater and groundwater to provide a sustainable supply for the region. The project focused heavily on water recycling, reduced consumption, better management, and the use of pioneering technologies (www.nwc.gov.au/resources/documents/RainwaterTanks.pdf). Other areas have been upgrading both their management and infrastructure, such as the Brussels-Capitol region of Belgium, which recently upgraded its sewer network to accommodate run-off from heavy rains. Recent government-supported research in the UK has developed and supported the implementation of Integrated Urban Drainage Management (IUDM) to combat urban flooding. A case study in Spain indicates that rainwater harvesting strategies in dense urban areas under Mediterranean conditions appear to be economically advantageous only if carried out at the appropriate scale in order to enable economies of scale, and considering the expected evolution of waterprices (Farreny et al. 2011). Also support for rainwater harvesting as a low-cost option has been reported in Bangladesh (Alam et al. 2011). Cost-effectiveness should be investigated in the local context since it depends on local precipitation, prices of water, urban density etc. If not only for reducing the demand for tap water, storage facilities can contribute to flood prevention in urban areas. Reducing flood risks in urban areas contributes positively to surface water quality, since floods in urban areas causes a discharge of nutrients and pollutants (for instance due to sewage system overflows). Urban renewal of buildings and infrastructure is one of the opportunities by which cities can adapt. The inclusion of pro-active retrofitting in regular urban renewal schemes and decreasing lifetime cycles of new buildings are likely sound and effective strategies to increase the robustness of the urban areas to climate change (Zevenbergen et al. 2008).
EU Policies concerned and institutional process	Water Framework Directive, Cohesion Policy, Floods Directive, Solidarity Fund, Council Reg (EC) N° 1083/2006, Eurocodes The measure is explicitly mentioned as a positive adaptation example in the EU CIS guidance "River Basins Management in a changing climate" and also in the EU communication "Addressing the challenge of water scarcity and droughts in the European Union" It could be funded under the cohesion policy.

Character of measure	Preventing/Reactive.
Sector(s) affected	Water management, industry, and domestic/tourism
Time to implement	Short term (5-25 yr).
Administration level	Regional / River basin.
Examples	Rainwater use eases pressure on the main water supply, reducing upstream energy and environmental costs. Also reduces rainwater overflow which is particularly problematic in those cities where rainwater and sewage water are not separated. Options in this measure include those for water storage and retention in or near city areas It is implemented through artificial infiltration and retardation, reduced impermeable area, pervious pavements and parking lots, local storages (ponds, building storages, groundwater cisterns); roof planting. It also includes increase of storage in the river system which can be achieved by development of flood plains, polders, and wetlands. Permeability taxation can enhance reconstruction of green areas in cities. By promoting infiltration, storage and trapping water in the catchments, flood peaks can be lowered. Improvement of drainage system can also enhance water storing.
Case studies	The area of Northern Adelaide in Australia has launched a collaborative program called, 'Water Proofing Northern Adelaide' that sought to improve urban water management in three cities. They achieved the integration of urban stormwater and groundwater to provide a sustainable supply for the region. The project focused heavily on water recycling, reduced consumption, better management, and the use of pioneering technologies. Other areas have been upgrading both their management and infrastructure, such as the Brussels-Capitol region of Belgium which recently upgraded its sewer network to accommodate run-off from heavy rains. Finally, recent government-supported research in the UK has developed and supported the implementation of Integrated Urban Drainage Management (IUDM) to combat urban flooding.
Reference	Alam, R., Munna, G., Chowdhury, M. A. I., Sarkar, M. S. K. A., Ahmed, M., Rahman, M. T., Jesmin, F. & Toimoor, M. A. (2011) Feasibility study of rainwater harvesting system in Sylhet City. Environmental Monitoring and Assessment: 1-8. Brown, R. R. & Farrelly, M. A. (2007) Advancing the Adoption of Diverse Water Supplies in Australia: A Survey of Stakeholder Perceptions of Institutional Drivers and Barriers. Report No. 07/04. National Urban Water Governance Program, Monash University. Case Study: Design and Operation of Sustainable Urban Infiltration Ponds Treating Storm Runoff Darwin Harbour WSUD Strategy (2009) http://www.equatica.com.au/Darwin/wsudst-definition.html. URL http://www.equatica.com.au/Darwin/wsudst-definition.html. de Graaf, R. E., Dahm, R. J., Icke, J., Goetgeluk, R. W., Jansen, S. J. T. & van de Ven, F. H. M. (2011) Perspectives on innovation: A survey of the Dutch urban water sector. Urban Water J. 8(1): 1-12. Ecologic, EEA (2009) Report on good practice measures for climate change adaptation in river basin management plans Factsheet: http://www.nwc.gov.au/resources/documents/RainwaterTanks.pdf Factsheet: http://www.nwc.gov.au/resources/documents/RainwaterTanks.pdf Farreny, R., Gabarrell, X. & Rieradevall, J. (2011) Cost-efficiency of rainwater harvesting

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Related to REFRESH-Measure	M353

MANAGING GROUNDWATER RECHARGE TO REDUCE WATER SCARCITY AND SALTWATER INTRUSION RISK

Measure Number	M04
Description	Managing groundwater recharge is a technique used in arid and semi-arid regions to recharge aquifers in a controlled way so that excess water can then be used later for water supply or environmental protection. A way of mitigating the threat of saltwater intrusion is systematically maintaining higher water table levels for groundwater, thus reducing the hydrological gradient from seawater.
Measure category	Technical Measure.
Measure sub-category	Changing management or practices.
Climate threat	Not enough water (scarcity & droughts), deteriorating water quality & biodiversity, too much water (flooding, sea level rise, coastal erosion).
Link to vulnerability	The measure reduces water stress impact (decrease of water availability due to saltwater intrusion) by decreasing the sensitivity state (and possibly pressure) for water quality (maintaining higher water table levels). *It is difficult to make distinction between climate change induced salt water intrusion and autonomous/human induced saltwater intrusion in a vulnerability assessment. However, it is clear that the measure mitigates both pressures on freshwater resources. Nature and drinking water supply will benefit from this measure without additional investments. For agriculture the measure is only effective in combination with additional adaptation measures on farm scale.*
Expert and stakeholder judgement	Subjected to a fast track assessment, the stakeholders assigned a low priority and urgency for the measure. This conclusion is derived from the performed multi-criteria analysis with input from stakeholders and experts (CSER 2011).
Qualitative assessment based on literature review	Climate change (precipitation, evaporation patterns, sea level rise) in combination with land subsidence (as a result of land use), changes in recharge and autonomous salinisation will affect coastal groundwater systems throughout the world (Sherif & Singh 1999; Ranjan et al. 2006; Masterson & Garabedian 2007; Oude Essink et al. 2010). Groundwater recharge is an indirect measure to increase the water supply within a managed water supply system. Contrary to rainwater harvesting which increases the water supply directly with additional water from natural precipitation, groundwater recharge feeds precipitated water into an aquifer in order to ensure and increase a continuous extraction of groundwater from this aquifer. The flow path of the percolating water together with mechanical and chemical filtering processes, and a considerable travelling and residence time, provides an effective filtering mechanism so that the extracted water has a generally high quality. Groundwater recharge does not face losses due to evaporation, as opposed to other methods that store water at the land surface, a particularly important feature in hot and dry climates. Water from groundwater recharge can be used, once

extracted, in the same way as any other groundwater resource.

The water used for recharging the aquifer can be taken from precipitation via reservoirs, but also from tertiary treated wastewater from water treatment plants. No major infrastructure investments are required for groundwater recharge; however, the existence of a groundwater body is a pre-requisite, and there must be considerable open land surface area available to be irrigated in order for it to infiltrate into the soil and eventually, for the recharge of the groundwater. The chosen piece of land has to be in hydrologic connection to the aquifer (to be recharged) which requires some hydro-geological expertise.

Groundwater recharge has the advantage of supporting a continuous groundwater flow along the natural flow paths, allows for an increased extraction of groundwater at already existing sites, maintains a higher groundwater level that serves agriculture as well as natural vegetation and ecosystem functions, and can prevent salty sea water intrusion at sites close to the sea.

Risks connected to groundwater recharge are predominantly related to the recharge of treated wastewater. Here, a thorough and permanent quality control of the water to be infiltrated in the soil is required in order to avoid polluting the entire groundwater body permanently or for a long period of time. In the case of recharging surface water the risk of pollution is less severe; nevertheless, surface water also requires treatment before being infiltrated into the ground.

A less controlled, but more sustainable alternative to programmed groundwater recharge consists of green infrastructure measures which, inter-alia may contribute to improve natural groundwater recharge by reducing surface run-off if adequate connections exist between surfaces and aquifers (Benedict and McMahon 2002; Mell 2008).

Solute transport of salt through porous media is a slow process, and in many delta's the groundwater system is not yet in dynamic equilibrium through processes which were initiated in the past, like lake reclamations or peat excavation. Land subsidence differs from place to place due to groundwater extraction, compaction and shrinkage of clay, and especially the oxidation of peat (Oude Essink et al. 2010). It is difficult to make distinction between climate change induced salinisation and autonomous/human induced salinisation in the evaluation of the performance of the adaptation measures.

Possible measures to reduce the vulnerability of groundwater systems to climate change are measures that will help to increase the recharge of the aquifer with freshwater or measures that reduce (the impact of) saline seepage on surface water and shallow groundwater. The following technical countermeasures are derived from literature (Oude Essink 2001; De Louw et al. 2010; Oude Essink et al. 2010):

(1) freshwater injection barriers through injection or(deep-well) infiltration of fresh (purified sewage) water near the shoreline;

(2) extraction of saline and brackish groundwater;

(3) modifying pumping practice through reduction of withdrawal rates or adequate relocation of extraction wells;

(4) land reclamation and creating a foreland where a freshwater body may develop which could delay the inflow of saline groundwater;

(5) increase of (artificial) recharge in upland areas, for example by inundation of land, to enlarge the outflow of fresh groundwater through the coastal aquifer and to reduce the length of the salt water wedge;

(6) creation of physical barriers, such as sheet piles, clay trenches and injection of chemicals.

(7) Climate compatible irrigation and drainage practices in agriculture in order to make efficient use of freshwater lenses in the root zone (Van Bakel et al. 2009; Suweis et al. 2010; Eeman et al. 2011).The dynamical behaviour of fresh water lenses – vital to sustain agriculture in areas prone to saline groundwater seepage – is highly dependent on spatially variable geological factors and their reaction to climate change is still poorly understood.

Described experiences with climate compatible groundwater table management

The Netherlands (Oude Essink et al. 2010)

The relative decrease in fresh groundwater volume in 2100 A.D. is marginal for the four KNMI climate scenarios (Van den Hurk et al. 2006) in comparison with the autonomous salinisation scenario as fresh groundwater volumes are enormous in the subsurface of this delta area. In absolute figures, the fresh groundwater resources reduce approximately between −200 and −2750 million m3.

In the same study technical counter measures (4) and (5) were studied, and judged as not effective for the Netherlands: (a) land reclamation offshore in the Noordzee induces a strong salt load to the existing surface water system, and (b) inundation of a large-scale low-lying polder area leads only to a marginal decrease in salt load. The authors finally conclude that it is not easy to stop salinisation of the groundwater and surface water system in the Netherlands in this way. Probably a combination of different human interventions is needed to decrease the salt load for the future. As such, the Dutch will very likely have to cope with much more saline groundwater in their coastal water system than at present.

Other information resources:

Custodio (2010) provides an overview of the state of art in coastal aquifer management in Europe (Custodio 2010). Particular European experiences with management of coastal aquifer management is described for Belgium (Vandenbohede et al. 2009) and Italy (Giambastiani et al. 2007). The European 7th Framework research programme GENESIS (on-going, see www.thegenesisproject.eu), evaluates 17 groundwater systems from 15 different European countries in view of current land use and future climate change.

The impacts of climate change on coastal aquifers in Asia (Bobba 2002) and in North-America (Barlow & Reichard 2010) is obviously different from Europe. However, the general picture is that groundwater management all over the world must face serious impact from future stresses (Ranjan et al. 2009; Post & Abarca 2010), so also experiences with climate compatible ground water table management outside Europe might include relevant information for European policy makers.

Salinisation of fresh water resources is a major research topic in the joint research programme of the Dutch drinking water companies coordinated by KWR Water research institute (http://www.kwrwater.nl/). Within the Knowledge for Climate programme (http://knowledgeforclimate.climateresearchnetherlands.nl/) this knowledge from the Dutch drinking water supply sector and KWR is combined with other expertise in relation to water management and climate adaptation. In order to prevent regional water shortages, the storage of rainwater, surface water, treated sewage or de-mineralized water in aquifers and/or surface reservoirs constitutes a possible adaptation measure. In two case studies (Haaglanden, Zuid Beveland) within the Rhine-Meuse delta (Southern part of the Netherlands) storage of surface water into aquifers is currently subject of research as an

	adaptation option to climate change within the Knowledge for Climate programme. Both regions are home to intensive horticulture and agriculture and are experiencing water shortages during times of peak demand and water quality problems in summer when water supplies are more saline. Two types of storage are considered: LSR-ASR, a new technology composed of a Leaky Storage Reservoir combined with phreatic Aquifer Storage and Recovery via the reservoir (Zuid-Beveland); and ASR (Pyne, 2005), a relatively proven technology of aquifer storage and recovery via wells that are used for both injection and recovery (Haaglanden). The objective is to store excess water of suitable quality during hydrological peaks for later use during periods of water shortage or peak demands. In the Netherlands, there is little experience with water technologies to store surface water in aquifers for later use by ASR, to desalinate brackish groundwater, e.g. by reverse osmosis (Stuyfzand and Raa, 2009) , and to dispose of the membrane concentrate by deep well injection. In addition, various polluted waters (like sewage effluent, drain water from greenhouse horticulture and rain water) may become an alternative water source, when treated with modern techniques that outcompete traditional expensive systems that require too much space or energy. However, implementation of these techniques is currently hampered by lack of knowledge on (i) their performance under Dutch hydrogeochemical conditions and (ii) their heavily counting environmental impacts (Jones&Pichler, 2007; Stuyfzand, 2002; Prommer and Stuyfzand, 2005; Stuyfzand et al., 2007), (iii) resistance within society.
EU Policies concerned and institutional process	EU Groundwater Directive The EU GroundWater Directive (GWD), in conjunction to the Water Framework Directive (WFD) provides means to protect groundwater aquifers from pollution and deterioration. Amongst others, existing and new guidelines regarding the next generation of drainage basin management plans will be critically revised or drafted, taking into account climate change, and thus include measures to reduce salt intrusion risks in coastal zones.
Character of measure	Preventing
Sector(s) affected	Water management, Agriculture
Time to implement	Short term (5-25 yr)
Administration level	Natrional, Regional / River basin, Municipality/company.
Examples	The main purpose is simply to store excess water for later use, while improving water quality by recharging the aquifer with high quality water (the addition of a fresher recycled water supply can displace saltier groundwater).
Case studies	Managed Aquifer Recharge (MAR) is already in use in various sites in Western Australia, such as the Perth region. CSIRO played a major role in developing national guidelines, a risk assessment framework, and demonstration projects. The method is also successfully in use in the US, Europe, South Africa, India, China, and the Middle East.
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Campling et al., (2008) Assessment of Alternative Water Supply Options. Final Summary Report (Extended Version). Study undertaken for the European Commission – DG Environment
http://ec.europa.eu/environment/water/quantity/pdf/Summary%20Report_extended%20version.pdf

CSER (2011) Workshop Report – Assessment results and Annexes Climate Adaptation – Modelling Water Scenarios and Sectoral Impacts (ClimWatAdapt) - 2nd Stakeholder Workshop -Wednesday, March 30th – Thursday, March 31st 2011, Ministry of Rural Development, Budapest, Hungary. In: Kassel: CSER.

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Forestry Strategies To Protect Floodplain Agricultural Systems, http://www.na.fs.fed.us/Spfo/pubs/n_resource/flood/strateg.htm

Giambastiani, B. M. S., Antonellini, M., Oude Essink, G. H. P. & Stuurman, R. J. (2007) Saltwater intrusion and water management in the unconfined coastal aquifer of Ravenna (Italy): A numerical model, . J. Hydrol. 340: 91–104.

http://www.clw.csiro.au/research/urban/reuse/projects/water_quality_mandurah.html

http://www.clw.csiro.au/research/urban/reuse/projects/water_quality_floreat.html

http://www.nwc.gov.au/www/html/529--water-recycling-via-managed-aquifer-recharge-guidelines.asp?intSiteID=1

Jones, G.W. & Pichler Th. (2007) Relationship between pyrite stability and arsenic mobility during aquifer storage and recovery in southwest central Florida. Environmental Science and Technology 41: 723-730.

Krysanova ; Buiteveld; Haase (2008) Practices and Lessons Learned in Coping with Climatic Hazards at the River-Basin Scale: Floods and Droughts www.newater.info/.../CAIWA-Climate-Hazards-krysanova-251007.pdf

MAR Guidelines providing a national risk assessment framework to ensure that water sourced from these schemes is safe in terms of human health and the environment:

Masterson, J. P. & Garabedian, S. P. (2007) Effects of sea-level rise on ground water flow in a coastal aquifer system. Ground Water, 45: 209-217.

Mell, I. C. (2008) Green Infrastructure: concepts and planning. Newcastle University FORUM Ejournal(8).

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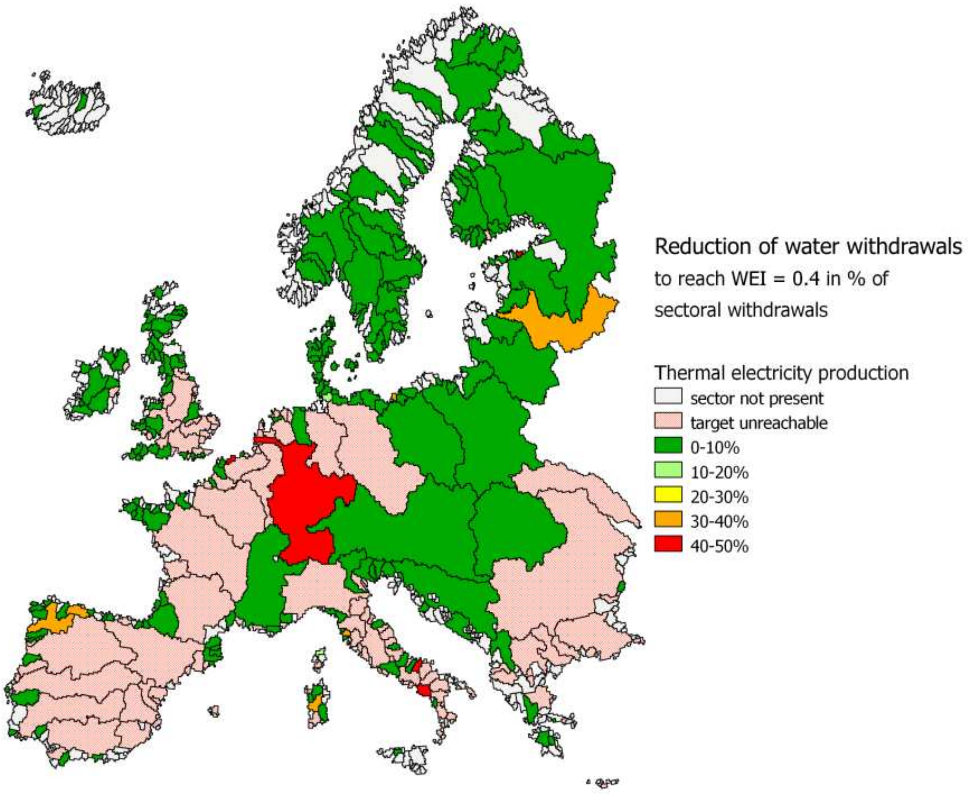
Vandenbohede, A., Van Houtte, E. & Lebbe, L. (2009) Sustainable groundwater extraction in coastal areas: A Belgian example Environ. Geol., 57, 735–747, 57: 735-747

REDUCING FRESHWATER DEMAND FOR INDUSTRIAL COOLING

Measure number	M05
Description	Using recycled water for industrial cooling reduces freshwater demand, which will make power plants less susceptible to climate-induced changes to water availability. Shift in cooling system.
Measure category	measure
Measure subcategory	Changing management or practices, Deteriorating water quality & biodiversity
Climate threat	Not enough water (scarcity & droughts)
Link to vulnerability	The measure reduces water stress (impact) by descreasing the sensitivity (state) of water use. Furtehremore, the measure directly influences demand management (pressure) by changing technology (driver).
Quantitative results from using the Integrated Assessment Framework (IAF)	 The map shows the water savings necessary to reach a target Water Exploitation Index WEI<0.4 expressed as percentage of the water withdrawals for cooling in thermal electricity production. This calculation for 2050 is based on WaterGAP3 results for water withdrawals und EcF and median water availability from the ensemble of hydrological model simulation with LISLOOD. Water savings for industrial as a single sector adaptation measure is only feasible in Northern and Eastern Europe. In Western and Southern Europe the target WEI

	will not be met this measure.
Expert and stakeholder judgement	The measure directly addresses some urgent and prioritized climate concerns and would be very important and useful. However, the measure is quite location-specific and thus its effectiveness. Measure is limited to power stations with closed-cycles; a retro-fitting can probably be very expensive. In order to use recycled wastewater for industrial cooling the infrastructure to wastewater treatment plants must be available. This will increase costs, too. As negative effect, power plants with closed-cycles for cooling use more energy which in turn may increase GHGs emissions. An alternative to this measure could be to use the hot water for a quite different process instead of cooling. The conditions for decision making like feasibility, combatibility, reach a medium level. The measures shows a high urgency & priority and also robustness. The negative side effects are low and positive side effects high. Overall, this measure was seen to be costly whereas the costs and benefits could regionally vary. Subsidies will be needed for building new facilities. During droughts emergency measures and restrictions for cooling water abstractions are already put in place in a lot of countries.
Qualitative assessment based on literature review	In the EU as a whole, energy production accounts for 44 % of total water abstraction, primarily serving as cooling water, however, the share varies between different regions (EEA 2009). Since the 1990s cooling water abstractions have slightly decreased, due to the implementation of new water saving technologies. This includes the replacement of older once-through systems with more advanced cooling technology, including recirculation, dry and hybrid systems. Despite these on-going replacements there is the potential for alternatives, e.g. using recycled or reclaimed water for cooling. Although reuse of treated wastewater is not a new practice, it is more popular in the agricultural sector for irrigation than in industrial locations. In order to be used for industrial cooling, reclaimed water must meet at least secondary treatment standards. Since cooling (and boiler feed) water does not typically need to be of high quality, alternative sources can be less impacted by drought than higher quality freshwater sources (EEA 2009). Reclaimed water represents a valuable water resource with many potential applications. As the power industry sites new plants or expands capacity at existing sites, it must identify sufficient supplies of water to cool the steam. Reclaimed water can help meet that need. In the U.S. about 50 power plants are currently using reclaimed water for cooling (Veil 2007). The State Government of Victoria (Australia) has introduced some guidelines for cooling towers and recycled waters. Here it is stated, that with appropriate management controls, alternative water sources can be used to supply or supplement cooling tower systems. The controls required will depend on the source of water used (Environmental Health Unit, Victoria Government 2008). Through integrated water resources planning, the use of reclaimed water may provide sufficient flexibility to allow water authorities, as well as individual users, to respond to short-term needs and to increase sustainable, long-term water supply reliability, without constructing additional storage or conveyance at substantial economic and environmental expenditures (Salgot and Huertas 2006). Among the variety of uses that reclaimed water may have in the industrial sector, cooling water is the most popular because the water is generally circulated in a closed system and does not have direct contact with humans or the environment (Salgot and Huertas 2006). Reuse of effluent can be a good option for certain industrial applications such as cooling systems. The use of reclaimed water by industry eases the pressure on scarce water

	resources in the region. (Angelakis et al. 2003) During the planning and implementation of water reclamation and reuse, the reclaimed water application will usually govern the type of wastewater treatment needed to protect public health and the environment, and the degree of reliability required for each sequence of treatment process and operations. Water reuse applications, from a global perspective, have been developed to replace or increase water resources for specific applications. Urkiaga et al. (2004) stated that overall, industrial activities represent the third major use of reclaimed water, primarily for cooling and process needs. Due to the fact that cooling water amounts for the largest industrial demand, the predominant industrial water reuse could either for cooling towers or cooling ponds. However, water quality requirements tend to be industry-specific and in order to provide adequate water quality, supplemental treatment may be required beyond conventional secondary wastewater treatment. The use of treated wastewater is quite different in those two regions: in the EU Mediterranean countries, treated wastewater is reused predominantly for agricultural irrigation and for urban or environmental applications, whereas in western and continental Europe, reuse occurs mainly in urban and environmental or industrial applications. Overall, the literature review has shown that the use of reclaimed water as cooling water for electricity production is not very common in Europe. However, it is more and more in the focus of water scarce regions. *Case Studies:* In Riga, cooling water from Riga Thermal Power Plant Number 1 was upgraded with cooling water being biologically treated in ponds and recycled afterwards, as opposed to freshwater being discharged into Lake Kisezers. The introduction of recycling of cooling water is expected to lead to a reduction from 30 million cubic meters per year to 3.1 million per year. Another example involves the provision of cooling water for a power plant in Poland (~ 2 Mm^3/a) which is prepared by membrane technology. A pilot plant with wastewater treatment plant effluent for the preparation of boiler feed water was successfully run in Hoogvliet (Netherlands). It is intended to commission a full-scale plant with a flow of 2.5 Mm^3/a (van Naerssen et al., 2001). Source: AQUAREC. The reused wastewater might stem either from the company's treatment facility (on-site recycling) or from a municipal wastewater treatment plant into which households and industries discharge. A large-scale system is operated for the textile industry in Prato, Tuscany (Italy). Industrial and municipal wastewater is reclaimed (3.5 Mm^3/a) and augmented to 5 Mm^3/a by river water withdrawal. A separate industrial aqueduct redistributes the reclaimed water to the enterprises. The steel industry in Piombino is provided with about 3.5 Mm^3 of upgraded wastewater. Source: AQUAREC.
Costs	Data on economic externalities on treated wastewater reuse is still lacking and more effort is needed to measure the true economic value of treated wastewater reuse. The economic value of treated wastewater in a sectoral application can be assessed by the corresponding conventional water price or the added value generated by the specific sector. The economic analysis (according to Art. 5 WFD) should regard water as a production factor such as material, work, energy, etc. and hence be able to put a figure to the value of treated wastewater. Wastewater reuse can be less costly than using freshwater. Life Cycle Cost analysis is a useful way to evaluate the conditions under which treated wastewater reuse can be cost effective and in comparing cost performances of different

	technologies and investment strategies. Setting appropriate tariffs for treated wastewater and subsidies are seen as an important incentives mechanism. Often water supply benefits alone cannot cover the project costs. The main barriers preventing the wider application of reclaimed water include a lack of network infrastructure, low financial returns, consumer reluctance, and weakly enforced regulation.
EU Policies concerned and institutional process	Water Framework Directive, WS&D-policy, Council Reg (EC) N° 1083/2006, Eurocodes, EU Sustainable Development Strategy (SDS), Communication on Resource Efficiency The BREF document for the Industrial Cooling sector does explicitly mention the reuse of reclaimed municipal wastewater as cooling water make-up as a best practice reference (EC, 2001). The communication on ressource effiency (COM(2011) 21), clearly aims to create a framework for policies to support the shift towards a resource-efficient and low-carbon economy. This also relates to water saving in industry, as sector that is seen as a key. For the water reuse side the actual implementation of projects is often based on regional guidelines, even though there is a trend to establish national standards on water reuse, too. On a supranational level, the WHO has issued Guidelines for the use of reclaimed water in agriculture, but there is a gap on EU level.
Character of measure	Preventing
Sector(s) affected	Energy sector; Industry
Time to implement	Short term (5-25 yr)
Admin level	National and Municipality/Company
Case studies	In Riga, cooling water from Riga Thermal Power Plant Number 1 was upgraded with cooling water being biologically treated in ponds and recycled afterwards, as opposed to freshwater being discharged into Lake Kisezers. The introduction of recycling of cooling water is expected to lead to a reduction from 30 million cubic meters per year to 3.1 million per year. Another example involves the provision of cooling water for a power plant in Poland (~ 2 Mm^3/a) which is prepared by membrane technology. A pilot plant with wastewater treatment plant effluent for the preparation of boiler feed water was successfully run in Hoogvliet (Netherlands). It is intended to commission a full-scale plant with a flow of 2.5 Mm^3/a (van Naerssen et al., 2001). Source: AQUAREC. The reused wastewater might either stem from the company's treatment facility (on-site recycling) or from a municipal wastewater treatment plant into which households and industries discharge. A large scale system is operated for the textile industry in Prato, Tuscany (Italy). Industrial and municipal wastewater is reclaimed (3.5 Mm^3/a) and augmented to 5 Mm^3/a by river water withdrawal. A separate industrial aqueduct redistributes the reclaimed water to the enterprises. The steel industry in Piombino is provided with about 3.5 Mm^3 of upgraded wastewater. Source: AQUAREC.
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ADAPT MANAGEMENT OF WATER LEVELS IN LAKES, DISCHARGES IN RIVERS, AND INUNDATION OF WETLANDS TO ENVIRONMENTAL NEEDS

Measure number	SA06
Description	Human developments alter significantly the water levels in lakes and wetlands and river discharge and this may cause significant environmental damage due to floods, water shortage, accumulation of nutrients and toxins and changes of habitats. Water level controls are management practices that may be the most socio-economic and environmentally balanced solution to protect threathen ecosystems and ecoservices. This management approach should be adapted on the basis of the best available information over climate variability and change and their impact on freshwater ecosystems in order to deal adequate with the increased flood and drought risks and improve the satus of these ecosytems. In this process substantial involvement of stakeholders in formulation of the problems and their solutions should be envisage to avoid impasses in decision making, making water management as a guiding principle in spatial planning.
Measure category	Support Action
Measure sub-category	Changing management and practices
Climate threat	Not enough water (scarcity & droughts), too much water (flooding, sea level rise, coastal erosion), deteriorating water quality & biodiversity.
Link to vulnerability	The measure reduces the impact on floods, water scarcity and biodiversity and ecosystem health via reducing the pressure and state of exposure through changes in (water) management practices.
Expert and stakeholder judgement	The measure can work out completely different for the scenarios floods and droughts. The measure is assessed to have a low urgency and priority, in case of flood management, because there are too many possible side effect. The measure can have a negative side effect by increasing water levels in wetlands and therefore reducing the options for water storage. In case of water scarcity and droughts the urgency and priority is relatively high, in order to meet environmental demands. However, when new regulation means new dams the priority decreases. Looking at the side-effects, the measure is positive for the environment but is conflicting for economic sectors since it might suppose restrictions. The win-win is for biodiversity. The performance under uncertainties is high, since management depends on climate change. The efficiency of the measure is unclear.
Qualitative assessment based on literature	Management of water levels, with a view to improve environmental water quality, is frequently possible due to the normal and emergency water storage capacity as well as the highly interconnected nature of many European water systems. Management of water levels influences the carrying capacity (pollution load the water body

review	can take up) of the system; influencing water levels (in for example rivers) can help avoid pollution levels passing the relevant thresholds (Ecologic draft report). In Southern European countries, this application is frequently implemented through the environmental flow requirements. Australia has even created the position of “environmental water managers”, giving them the necessary authority and resources to provide sufficient water at the right times and places and allowing them to trade water. (http://www.nwc.gov.au/www/html/227-environmental-water-management.asp). Another application of this measure principle is “Flushing of brackish river water during dry periods”. In the Netherland water bodies in polders are at risk of intrusion and seepage of silt water and discharge of pollutants. Flushing of these water bodies with fresh water of the rivers has been made possible by a series of (movable) dams in the branches of the river Meuse and river Rhine. (http://www.safecoast.org/editor/databank/File/flood%20management%20and%20climate%20change%20in%20NL.pdf)
EU Policies concerned and institutional process	Water Framework Directive, Habitat Directive, Floods directive, WS&D policy, Natura2000, Integrated Coastal Zone Management This measure could be applied in the context of the WFD and to achieve biodiversity goals. However there is a risk that additional infrastructure needed will negatively impact at other parts of the river.
Character of measure	Preventing, reactive, recovery.
Sector(s) affected	Water management, Agriculture, Forestry; Energy, Navigation
Time to implementation	Mid-long term (> 25 years)
Administration level	From river basin to community level
Examples	Examples of adaptive management of water levels are: 1. the use of the environmental flow requirements, 2. to flush brackish river water during dry periods, 3. management of water levels influences the carrying capacity (pollution load the water body can take) of the system; 3. influencing water levels to avoid high pollution levels and sea water intrusion.
Case studies	Environmental flow requirements are frequently implemented in Southern Europe. The Netherlands is currently evaluating the option of using stored water to flush brackish rivers during dry periods. This would both dilute and flush out the brackish water, thus improving water quality.
Reference	Australia, environmental water managers. http://www.nwc.gov.au/www/html/227-environmental-water-management.asp Ecologic, EEA (2009)Report on good practice measures for climate change adaptation in river basin management plans Institute for Environmental Studies (2001) Floods, flood management and climate change in The Netherlands. Vrije Universiteit http://www.safecoast.org/editor/databank/File/flood%20management%20and%20climate%20change%20in%20NL.pdf

Related to REFRESH measures	M045, M050, M032

RISK POOLING AND INSURANCE

Measure Number	SA07
Description	Risk pooling and insurance are a specific category of economic instruments. Their aim is to take away the burden of losses due to climate or weather extremes and make the impacts of such events bearable. The supporting actions can take form of insurance, catastrophe bonds, weather derivatives or there like.
Measure category	Support Action
Measure sub-category	Economic and financial
Climate threat	Too much water (flooding, sea level rise, coastal erosion), not enough water (scarcity and droughts), deteriorating water quality and biodiversity, snow.
Link to vulnerability	Can address all sensitivity indicators. Economic instruments can only marginally decrease the probability of flood or drought events, this happens for instance when they reduce those human behaviours which contribute to the events e.g. an excessive/inefficient use of water. They are more effective in reducing vulnerability ex post. This is primarily the role of risk alleviating economic instruments, but can apply also to tariffs and charges, when the generated revenues are earmarked to finance appropriate anticipatory and reactive adaptation measures (e.g. technical and social preparedness against floods, irrigation and water storage system against droughts, support to post-event recovery programmes).
Expert and stakeholder judgement	The stakeholders attributed some relevance to insurance and risk pooling schemes at European level, but not considered these as the highest priority.
Qualitative assessment based on literature review	Insurance is the typical risk sharing/alleviating instrument. The insured pays a premium the insurer that covers the risks regarding either one or more variables and indemnify only after the assessment of losses caused by the specified variables. Catastrophe bonds securitise risks associated with natural hazards (in the specific case floods-droughts). In particular, reinsurance companies and large corporations issued cat bonds in order to reinsure or retrocede these low frequency – high severity risks appearing on their balance sheet (Haupter et al., 2005). Weather derivatives are derivative securities (taking most commonly the form of futures) in which an investor hedges against the future state of the weather. For example, one investor pays another if a weather indicator (rainfall, temperature, number of heating or cooling degree days, soil humidity) in a given place over a given period of time is above a certain amount. Likewise, the other investor pays if the indicator is below the agreed-upon amount. The role of insurance in drought and in flood management is important for two reasons. First, it provides the necessary funding for the recovery phase of the risk management cycle. Secondly, insurance companies have more direct access to home owners and can demand prevention measures when setting the level of insurance premiums (FLAPP, 2007). If for instance flood damages were covered by state funds only, there would be limited

	incentives for those in the private sector to minimise their own risks. This is partly the case of France (Botzen and den Berg, 2008). The French system is characterized by a high degree of solidarity, since premium differentiation is not allowed and the insurance scheme is kept affordable with public reinsurance. The public reinsurance solves problems associated with high correlated risks. But the drawback of the absence of premium differentiation is that this impairs efficiency by failing to reward development in low-risk areas and loss-mitigating investments. On the other hand, just private insurance has drawbacks too. For instance the flood insurance market in the United Kingdom is closest to a pure private market because premiums are risk based, the government is not involved as a reinsurer, and a public compensation scheme is absent. This makes insurance premiums relatively expensive, which, in combination with the voluntary nature of the market, may explain a low coverage among poor households. Therefore, multilayered insurance programs seem to be a promising public-private partnership that can provide adequate incentives to limit flood losses and overcome capital shortages in insuring large catastrophe losses. All natural hazards should be incorporated in a single contract, since most hazards like flood, storm, earth slides, hail and heavy rainfall generally occur in the same event, which makes it difficult to separate out the damage that corresponds directly to the insured hazard. Since every place is exposed to some natural hazard, the creation of a larger (cross-border) insured community leads to lower premiums.
EU Policies concerned and institutional process	Currently, there is no European policy that applies to the insurance sector. Potentially, the insurance in agriculture may be introduced in connection to the Common Agricultural Policy. The Solidarity Fund could be connected with insurance in order to guarantee coverage in areas or sectors that are not commercially viable.
Character of measure	Preventing, preparatory, recovery.
Sector(s) affected	Water management, agriculture, energy, industry, forestry, navigation, domestic/tourism.
Time to implement	Short term (5-25 yr), mid to long term (25+ yr).
Administration level	National, Regional or River Basin, Municipality/company.
Case studies	Many examples of changing financial aid arrangements come from the developing world. In Zimbabwe, researchers experimented with shifting from an ex-post to an ex-ante strategy to reduce drought damages. They found evidence that ex-ante payments do reduce poverty in non-drought years. In the Dominican Republic, the Inter-American Development Bank's risk management approach is focused on disaster risk management and prevention.
Reference	Botzen, W.J.M and J.C.J.M. van den Berg (2008), "Insurance against climate change and flooding in the Netherland: present future and comparison with other countries", Risk Analysis, 28, 2: 413-426. EEA (2007) " Climate change and water adaptation issues", EEA Technical report 2/2007. Hurduzeu G. and L.G. Constantin (2008), "Several Aspects Regarding Weather and Weather Derivatives", The Romanian Economic Journal, Year XI, no. 27 International Institute for Applied Systems Analysis, Financial Disaster Risk Management and Catastrophe Simulation Modeling, http://www.iiasa.ac.at/Research/RMS/Projects/Risk_Management.html?sb=6

	Keating, M.: A governmental speech on water pricing in Australia. http://www.ipart.nsw.gov.au/files/Speech%20on%20Water%20Pricing%20and%20Its%20Availability%20by%20Michael%20Keating.PDF Mattheiss, V., Goral F., Volz P. and P. Strosser (2010), “Economic instruments for mobilizing financial resources for supporting IWRM”, ACTEON OECD (2010): Pricing Water Resources and Water and Sanitation Services, Paris, France Roth , E. (2001), “Water Pricing in the EU. A review”, European Environmental Bureau, PN 2001/002 Rural demand for drought insurance, http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1994/11/01/000009265_3970716141945/Rendered/PDF/multi_page.pdf Stern, H., 2001: The application of weather derivatives to mitigate the financial risk of climate variability and extreme weather events. Aust. Meteor. Mag., Vol 50, September 2001. Strategies and Financial Instruments for Disaster Risk Management in Latin America and Caribbean, http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=823517 Strosser, P. (2008): Environmental and economic impacts of water pricing in agriculture. http://www.ecologic-events.de/cap-wfd/conference3/documents/Strosser.pdf UN policy brief on agricultural insurance in developing courtiers, http://www.un.org/esa/sustdev/publications/innovationbriefs/no2.pdf
Related to REFRESH-Measure	M004

FUNDING PROVISION AND SUBSIDIES

Measure Number	SA08
Description	Economic incentives can spur behavioural change through financial reward or penalty; or change conditions to enable economic transactions. Rather than specifying a particular type of behaviour that the regulatee has to comply with, economic incentives encourage or discourage certain behaviour, usually through price signals, but leave the choice to the regulatee
Measure category	Support Action.
Measure sub-category	Economic and financial.
Climate threat	Too much water (flooding, sea level rise, coastal erosion), not enough water (scarcity and droughts)
Link to vulnerability	Can address all sensitivity indicators...Economic instruments can only marginally decrease the probability of flood or drought events, this happens for instance when they reduce those human behaviours which contribute to the events e.g. an excessive/inefficient use of water. They are more effective in reducing vulnerability ex post. This is primarily the role of risk alleviating economic instruments, but can apply also to tariffs and charges, when the generated revenues are earmarked to finance appropriate anticipatory and reactive adaptation measures (e.g. technical and social preparedness against floods, irrigation and water storage system against droughts, support to post-event recovery programmes).
Expert and stakeholder judgement	Economic incentives towards for example greater application of water efficient appliances received high support from the stakeholders. Adjustment of the minimum requirements for European funding was also constructive, some concerns were raised with respect to the implementation of these provisions. Negative side effects have been found negligible. The supporting actions have been considered robust and efficient: the expected benefits have been considered higher than the associated costs.
Qualitative assessment based on literature review	Economic or market-based instruments refer to those tools that, acting on the price system, correct undesired or induce desired distortions in agents', firms or households, behaviour. The main advantage of these instruments is economic efficiency, i.e. the ability to distribute the burden of the distortion reduction where it is cheaper to do so. The drawbacks are on the equity side, as they affect differently different agents or social groups not necessarily in a progressive way, and strictly linked to this, on the political feasibility side. Economic instruments are traditionally classified in taxes and charges (water tariffs, environmental taxes and charges), subsidies (on products and practices), market mechanism for environmental goods (tradable permit for pollution or water abstraction, compensation mechanisms), and voluntary agreements. Water pricing in the form of taxes and abstraction charges are in place in a number of OECD countries (EEA, 2007; OECD, 2010). In the OECD different systems can be found, varying by country and sector. They target in priority households and industry. The agricultural sector may sometimes benefit from lower rates (Seine Normandie river basin, France) or of possible implicit exemptions

	(Netherlands). Charges are volumetric in most cases, with the user paying a unitary rate per cubic meter abstracted (e.g. Germany, Estonia, the Netherlands, Bulgaria). Other structures are for example fixed charges per hectare for non-metered agricultural abstraction (Seine-Normandy river basin, France) or nominal license fees linked to an abstraction permit regime (United Kingdom). The charges are often further differentiated by user type or source and vary often between regions. The Baltic countries for example differentiate between different ground water layers and the catchment area (Mattheis et al., 2010). The main pursued effects are: (1) to signal the “true” scarcity of the water resource, (2) induce users to respond to it possibly reducing water demand/inefficient uses, (3) allocate water uses where they are more needed (Roth, 2001). The ends are thus “environmental” (this reinforced by pollution charges) preventing the depletion of an important natural asset, and “efficiency-oriented” ensuring that water is allocated to the most beneficial uses and economic resources are not wasted. By meeting these objectives, economic instruments can partly prevent drought events, but most importantly can decrease the severity of a drought event when this happens. Moreover, abstraction charges and taxes are mostly collected by regional or local authorities and are designed with the objective of providing funding for water resources management or for watershed protection activities (OECD 2010). This earmarking of revenues, which supports the resource conservation provides a further buffer against the effects of droughts when they materialize. For completeness, the other objectives associated to economic instruments are quoted (OECD 2010): the first is financial i.e. generation of revenues. The second is social, i.e. guarantee an adequate access to affordable water at fair and equitable conditions (avoiding market power, provide access to low-income groups, share equitably the cost of the management of water resources). Taxes play an obvious role also in flood prevention/protection and recovery as countries and often local public administrations usually finance these activities with general or dedicated taxation. It has to be noted that the task of preventive flood protection presents a classical upstream–downstream problem. The benefits, costs and other burdens of preventive actions to lower the discharge peaks are in different geographical locations and, as a rule, also affect different interest and actor groups. The current principles of financing flood protection measures by the countries themselves do not provide for any compensating effects between diverging costs and benefits in transnational river basins and do not include the use of incentives. In this context financial compensation and economic incentives could be designed to strengthen the principle of the ‘‘causer pays’’ for future uses in flood plains, create incentives for local/regional measures by providing compensation for disadvantages, be based on the interconnections between measures and effects, including cost sharing, create the acceptance for a higher level of transparent negotiations and processes. (Haupter et al 2005)
EU Policies concerned and institutional process	Under the Water Framework Directive Article 9 it is required that Member States must ensure by 2010 that water-pricing policies provide adequate incentives for users to use water resources efficiently. However as a first assessment of the River Basin Management plans shows, there is little effort to set proper prices in most Basins. In 2007 the European Commission addressed this challenge in a Communication on water scarcity and droughts in the European Union (COM (2007) 414 final). The Communication identified 7 main policy options to address water scarcity and drought issues of which putting the right price tag on water it mentioned as the first option in the hierarchy of option.

	Detailed analyses of water pricing in agriculture and the need of possible adjustments of EU policies are currently deeply investigated in two EU services contracts, namely: “Water savings in agriculture” and “Water pricing in agriculture”.
Character of measure	Preventing.
Sector(s) affected	Water management, agriculture, energy, forestry, domestic/tourism.
Time to implement	Short term (5-25 yr)
Administration level	National, Regional or River Basin, Municipality/company.
Examples	E.g. Spain introduced conditions to the granting of funds for irrigation systems: • no new irrigation infrastructure or expansion of irrigated land can be funded • all investments related to irrigation must demonstrate water savings (measured through two additional indicators — total water savings and water savings per hectare); For instance, a rebate scheme covers water saving products such as three-star water efficient showerheads, upgrading to eligible dual flush toilets, garden products, rainwater tanks and systems for reusing household waste water.
Case studies	Rural Development Programmes under the Common Agricultural Policy offer the possibility to fund measures that improve irrigation efficiency. CAP Measure 121 (modernization of holdings) provides investment support to improve irrigation efficiency through technical investments at farm (parcel) level, whereas measure 125 (infrastructure investments) aims to improve the efficiency of the distribution infrastructure. Spain introduced conditions to the granting of funds: no new irrigation infrastructure or expansion of irrigated land can be funded and all investments related to irrigation must demonstrate water savings (measured through two additional indicators — total water savings and water savings per hectare). Funding for water retention in drought-endangered agriculture and forest landscapes was included in Germany's 2008 'Report on active climate protection in the agriculture, forestry and food industries and on adaptation of agriculture and forestry to climate change.' They suggested that the federal government must offer such incentives. The Thames Gateway stretches for 40 miles along the Thames Estuary. The area is already experiencing serious water stress, but has plans for around 160000 new homes to be built by 2016. The Environment Agency in England aims to make the new housing development water neutral. A bundle of measures is seen to be key to reaching water neutrality: new homes and offices are built to high standards of water efficiency; a high number of existing homes and buildings are retrofitted with water-saving devices such as low-flush toilets and low-flow taps and showerheads; and water metering becomes compulsory. Introducing variable water tariffs is also evaluated as a possibility to contribute to water neutrality. In July 2007, the European Commission published a Communication on water scarcity and droughts. It presents policy options to address this challenge, placing the need to use water more efficiently and to develop more sophisticated demand management strategies at the centre of its deliberations.
Reference	Botzen, W.J.M and J.C.J.M. van den Berg (2008), “Insurance against climate change and flooding in the Netherland: present future and comparison with other countries”, Risk Analysis, 28, 2: 413-426. Ecologic, EEA (2009):Report on good practice measures for climate change adaptation in

	river basin management plans EEA (2007) " Climate change and water adaptation issues", EEA Technical report 2/2007. Federal Ministry of Food ,Agriculture and Consumer Protection (2008): Report on active climate protection in the agriculture, forestry and food industries and on adaptation of agriculture and forestry to climate change, Germany. www.bmelv.de/cae/servlet/.../23673/Reportonactiveclimateprotection.pdf Mattheiss, V., Goral F., Volz P. and P. Strosser (2010), "Economic instruments for mobilizing financial resources for supporting IWRM", ACTEON OECD (2010): Pricing Water Resources and Water and Sanitation Services, Paris, France Roth , E. (2001), "Water Pricing in the EU. A review", European Environmental Bureau, PN 2001/002
Related to REFRESH-Measure	M212/M245

IMPROVED WATER RETENTION

Measure Number	M06
Description:	Increasing the water retention capability in rural areas can either aim to increase the natural water retention capacity of a landscape, or increase the water storage capacity with man-made structures. Natural water retention can be improved by techniques like creating wetlands and increasing soil cover. Additional water storage capacity can be achieved with structures such as off-stream polders or flood retardation ponds. Winter water storage reservoirs reduce abstraction during the summer, increase flood storage capacity, and benefit wildlife. Compensation may facilitate the implementation and operation.
Measure Category	Measure
Measure Sub-Category	Land use change and management
Climate threat	Too much water (flooding), and to a lesser extend not enough water (scarcity & droughts) and deteriorating water quality & biodiversity
Link to vulnerability	The measure reduces flood risks for people and assets in affected area by decreasing the exposure pressure on excess water through increasing retention capacity in the upstream area. In addition a reduction of water scarcity and drought and improving water quality and biodiversity is realised by reducing the exposure pressure of water availability through realising a slow water release from stored surface water and groundwater.
Quantitative results from using the Integrated Assessment Framework (IAF)	A small number of local area impact studies focus on quantitative results (see literature overview)
Expert and stakeholder judgement	This type of measure is potentially interesting because the design is often multi-functional and thus combines interests. Parallel to climate adaptation other users may benefit (nature/biodiversity development, recreation, tourism, landscape planning, green-blue services in agriculture) and as such this type of measure contributes to several EU policies (Natura 2000, second pillar of CAP). In most cases this type of measure is considered promising, although characteristics of locations must be considered before implementation, because these measures do not function everywhere. Adequate compensation of land owners is necessary and projects must not only address design and implementation, but also behavioural change of land users. Management of water retention is needed as there are risks of failure with cascading effects on discharges. An issue in planning and implementation is the complexity of governance and coordination as usually private and several public parties are involved. In a short track assessment at the CWA stakeholder workshop a high priority was pointed out by the stakeholders.
Qualitative	Much literature on this topic is about specific cases and is addressing planning and policies

assessment based on literature review	(Brandenburg, Saxony, Green blue services in the Netherlands, South East England Regional Assembly). There is a small number of publications on experiences and on effectiveness and risks of water retention in rural areas in general. Krysanova et.al. (2008) analyse six river basins in an attempt to draw generic lessons. Water retention in rural areas is part of the analysis. Specific attention is paid to water storage reservoirs for flood control on agricultural lands and off-stream polders or flood retardation ponds. The importance of this type of measures is recognized in all basins (Amudarya, Elbe, Guadiana, Orange, Rhine, Tisza) although the implementation differs between the river basins. In the Rhine and Elbe basins these measures are part of a flood management strategy which gives first priority to retention measures, second priority to storage and last priority to discharge. This strategy aims at slowing down extreme runoff to mitigate high river discharges, while at the same time safeguarding water for times of scarcity. Local area analysis of small scale retention measures on rural areas show potential effectiveness in coping with extreme runoff events and increasing water availability in dry periods. (Juszczak et.al., 2007) However micro design of measures which takes local conditions in consideration is necessary, because the risk of adverse effects is existent. Also risks of damage to agricultural crops, due to higher groundwater tables must be considered (De Louw et.al.) Both cited studies are based on cases in relatively flat regions. In hilly or mountainous regions effectiveness is expected to be much lower or non-existent.
Costs	As the effectiveness of measures depend on local physical conditions (slopes, soils, existing drainage and water supply infrastructure, groundwater regimes) it is by definition impossible to quantify contribution to decreases of vulnerability in general.
EU Policies concerned and institutional process	WFD, Flood Directive, WS&D policy, Rural Development Regulation, Birds Directive, Habitat Directive, EU Biodiversity Action Plan, Solidarity Fund, Common Agricultural Policy, Council Regulation (EC) N° 1083/2006 lays down general provisions of the European Regional Development Fund, the European Social Fund and the Cohesion Fund. This measure can be implemented throughout a broad set of policies (as mentioned above). Funding is also provided under the Common Agricultural Policy. However the uptake of this measure is limited by conflicting land use interested trigged by the first pillar of CAP and renewable energy policies (bioenergy production).
Character of measure	Preventing, recovery
Sector(s) affected	Water management, Agriculture, Industry
Time to Implement	Short term period (5 – 25 years) as well as long term (>25 years)
Administration level	Regional or River Basin, and Municipality/company in lesser extend.
Examples	The natural water retention capacity of a landscape can be improved by: - checking and rebuilding old drainage systems - establishing a variable water flow regime - reconstructing/adapting hydromorphological structures in rivers - creating wetlands - creating lakes and wetlands in previous polders - increasing soil cover

	- setting up of flood control reservoirs / natural retention polders, which are both very different varieties of water impoundments, typically with large capacity and designed to only take up water levels that have been reached. - Water storage on farmland is defined as the storage of excess water, either in the soil under low groundwater conditions, in open water-like ditches, water courses, lakes and ponds or on the soil surface, assuming the soil and open water offer insufficient storage capacity.
Case Studies	The Netherlands has established many new water retention areas and emergency reserve lands as a safeguard against flooding and a way to reduce excess drainage of usable water. Most of these areas are a part of the program 'Room for the River.' Similar programs exist in Bavaria (The Bavarian Flood Management Plan) and England (Making Space of Water). In 2009, the Ukraine planned to construct 42 dry flood retention reservoirs in mountainous part of the Tisza basin as part of the ICPDR Sub-Basin Level Flood Action Plan for the Tisza River Basin. They primarily serve a flood protection role. The Climate Change Mitigation and Adaptation Implementation Plan for South East England contains measures for increasing flood storage capacity and developing sustainable new water resources. They argue that compensatory flood storage should be required through DPD policies and SPDs with Local Planning Authorities and Environment Agency input to scheme design. They also encourage the inclusion of policies in LDDs that encourage agricultural winter water storage reservoirs and other sustainable farming practices which reduce summer abstraction (and reduce diffuse pollution and runoff). They also urge the use of rural land use management and agri-environment practices to help deliver flood risk management. Finally, they aim to include a greater emphasis on flood risk management within objectives of environmental stewardship, include specific flood storage options in CFMPs, include requirements to safeguard land, incorporate flood storage requirements as part of developments within LDDs, and offer incentives to landowners to provide flood storage.
Reference	Collingwood Environmental Planning and Land Use Consultants. Climate Change Mitigation and Adaptation Implementation Plan for the draft South East Plan, 2006. http://www.espace-project.org/publications/library/climate_change_implementation_plan-300306-v2.PDF De Louw P. Van Bakel J. Buma J. Hakvoort H. Veldhuizen A. (2006) Vergroting Retentiewerking. Duurzame Watersystemen, TNO. Rapport: 2006-U-R-122/A Ecologic, EEA (2009)Report on good practice measures for climate change adaptation in river basin management plans Federal State of Brandenburg _Germany. 2007-2008. Integrated Climate Protection Management & Catalogue of measures for climate mitigation and climate adaptation. Federal State of Saxony-Germany (2009) Report on the state of implementation of the Climate and Energy Action plan of Saxony. Flood polder Riedensheim: http://www.tatenbank.anpassung.net/cln_095/Tatenbank/DE/1_MassnahmenDB/measureDetails_node.html?measureId=724 Future Proofing Perth's Eastern Region: Adapting to climate change. Regional climate change adaptation plan 2009-2013 www.emrc.org.au/.../Regional-Climate-Change-Adaptation-Action-Plan-2009-2013-29-October.2009. Juszczak R. Kędziora A. Olejnik J. (2007) Assessment of Water Retention Capacity of Small Ponds in Wyskoć in Western Poland. Agricultural-Forest Polish J. of Environ. Stud. Vol. 16, No. 5. P. 685-695

	Krysanova, Buiteveld, Haase (2008) Practices and Lessons Learned in Coping with Climatic Hazards at the River-Basin Scale: Floods and Droughts www.newater.info/.../CAIWA-Climate-Hazards-krysanova-251007.pdf Nillesen, E. E. M. and van Ierland, E. C. (Eds.) (2006) Climate adaptation in the Netherlands, Netherlands Programme Scientific Assessment and Policy Analysis Climate Change, Netherlands Environmental Assessment Agency Bilthoven, NL. Project: SAFECOAST; Quick Scan Climate Change Adaptation, With a focus on coastal defence policies in five North Sea countries. Dutch Ministry of Transport, Public Works and Water Management, National Institute for Coastal and Marine Management. January 2007. www.waddenvereniging.nl/klimaatverandering/pdf/PDF_273.pdf REFRESH. http://publications.jrc.ec.europa.eu/repository/handle/111111111/15801 Westerink, J., Buizer, M. and Ramo, J. S. (2008) European lessons for Green and Blue Services in The Netherlands, Working paper. Module 3. 6th Framework Programme PLUREL-project (Periurban Land Use RELationships). Alterra, Wageningen UR, Wageningen, NL. http://www.plurel.net/images/European%20lessons%20Green%20and%20Blue%20Services%20june%202008.pdf
Related to REFRESH Measures	M027, M162, M170, M372

ESTABLISHING WOODED RIPARIAN AREAS

Measure Number	M07
Description	Vegetated and unfertilized buffer zones alongside watercourses act as a shield against overland flow from agricultural fields and reduce run-off from reaching the watercourse, thus decreasing erosion and the movement of pollutants into watercourses. Prevention of sea level rise and increased flooding - potential for erosion in shore zones and for the impact on vegetation to worsen impacts of inundation.
Measure category	Measure.
Measure sub-category	Land use change and management
Climate threat	Too much water (flooding, sea level rise, coastal erosion), deteriorating water quality & biodiversity.
Link to vulnerability	The measure reduces flood impacts (run-off reaching the watercourse, erosion, pollution) by decreasing the sensitivity (pressure) through changes in land use. It reduces flood risk (people and assets flooded) via addressing exposure state indicator high water levels. The measure also reduces pressure (sensitivity) by improving risk management practices.
Expert and stakeholder judgement	The stakeholders gave high value to the measures aimed in establishing wooden riparian areas. However the not easy implementation has been pointed out, with some perplexities about the urgency of the adoption of the strategy. High value has been attributed to the possibility to implement a measure aimed to create buffer strips between water bodies and agricultural fields and within fields: jointly with the measure aimed to protect buffer vegetation in shore zones, high benefits have been pointed out even in case of less pronounced climate change impacts. Both these strategies presents, for the experts and stakeholders, negligible side effects and favourable conditions for the adoption by decision makers.
Qualitative assessment based on literature review	Riparian buffers may be constituted by any type of vegetation along riverbanks, lakeshores, or other adjacent land to other surface waters. Wooded riparian areas are, however, more widely advocated as an effective way to provide water protection. Wooded riparian buffers provide several environmental services but are mostly documented by their ability to increase water quality. By reducing erosion, forest buffers decrease the number of sediments entering water flows, serving also as filters, and thereby reducing the negative impacts of agriculture pesticides and fertilizer use (O'Laughlin and Belt, 1995). Streamflows surrounded by wooded riparian buffers have also been identified to have larger populations of process pollutants insects, which results in the provision of higher water quality (Margolis 2004). The benefits of improved water quality may be substantial. A study by the U.S. Department of Agriculture study concludes that the 40 to 45 million acres of cropland removed under the Conservation Reserve Program (CRP) generated an annual benefit of water quality improvement ranging from \$3.5 to \$4.5 billion, at an annual cost of \$1 Billion (Lynch et Tjaden 2000). Another study, performed by the Trust for Public Land and the American Water Works Association (Hopper and Summers

2004) concluded that forest cover in a watershed reduces water treatment costs. According to these authors a 10 percent increase in forest cover, decreases treatment and chemical costs by circa 20 percent. In addition, a large number of studies found evidence of public willingness to pay for higher water quality. Crutchfield et al 1997 performed a survey where respondents revealed that they would be willing to pay $45 - $60 per month to reduce risk of nitrate exposure.

Forest buffers may also reduce the risk of flooding, as the vegetation in the buffer decreases flood water speed, trapping also sediments and other materials carried by floodwaters. Hamilton 2008 has argued, however, that such a benefit has been overestimated and that forest buffers cannot realize substantial flood reduction. According to this author, benefits from flood reduction have been proved only “at the very local scale of a few hundred hectares”.

Finally, riparian buffers are also important for other ecosystem services, such as habitats for flora and fauna. Forested buffer zones are more likely to supply large woody debris, that increases fish habitat diversity. Forests also provide habitats for various bird species and terrestrial wildlife, cool down water temperature and supply leaf and fruit debris for aquatic food chain (Hamilton 2008).

The reports from the EU REFRESH research project (Nõges et al. 2010) present well documented evidence regarding the high potential for controlling nitrogen pollutants (including nitrate) and phosphorus of vegetated buffer strips. The performance is strongly dependent on characteristics such as buffer zone width, slope of the drained field, the nutrient load from the river and/or agricultural land (Hefting et al. 2003) , soil type and variety, and density of zone vegetation.

A general, multi-purpose, riparian buffer design consists of a strip of grass, shrubs, and trees between the normal bank-full water level and cropland (Anbumozhi et al. 2005). Buffer plants such as Phragmites communis and Typha latifola can also be used to create a riparian reedbed system which will act as an effective substrate–plant biofilter(Nõges et al. 2010).

Hefting et al. (2003) found that increasing nitrate load to riparian buffer zones leads to reduced nitrogen concentrations in the surface water but may also lead to increased emission rates of nitrous oxide (greenhouse gas) from the buffer strip into the atmosphere. Also research in peat fen meadows in the Netherlands show that the annual Greenhouse gas budgets (N_2O, CH_4, CO_2) for many land cover types is dependent on local water and land management conditions (Hendriks et al. 2007; Jacobs et al. 2007; van Beek et al. 2010) as well as strong relations between vegetation composition and CH_4 fluxes along the banks of water streams(Schrier-Uijl et al. 2010). From this research it is concluded that the greenhouse gas balance as well as the carbon balance can switch from positive (release of greenhouse gases) to negative (uptake of greenhouse gases) if agricultural peatlands allong streams are rewetted and agricultural practices have been reduced, which is the purpose of buffer strips. This reduction is estimated to be 24.8 tons CO_2-equivalents per hectare per year, if farm-based emissions are included (Schrier-Uijl 2010).

Additionally, suspended solids and sediments (with absorbed pollutants such as phosphorus) are filtered and channel erosion is reduced; potential for protection against pesticides and heavy metals is also judged to be very high. Buffer strips also effect a reduction in pollution by changing land use (i.e. stopping agricultural activity in the buffer area), they provide (additional) habitat for aquatic species and may result in increased recharge of groundwater.

Buffer strips are being widely supported as agri-environmental measures in European rural development programs, for instance in Spain; a typical value for buffer strips’ width is around 5 m. Wider buffer strips, which provide additional protection but used to be considered too costly, are finding additional support: a new option of the English

	Environmental Stewardship program supports 12 m wide buffer strips for watercourses on cultivated land. Based upon fish migration criteria the recommended width of a buffer is 10 m for upland streams and 100 m for lowland (Hendry et al. 2003). These strategies are also used to manage salt marshes. Salt marshes in front of dikes are not always acknowledged as being part of the flood protection zone in coastal areas. However, like dunes, also salt marshes in front of dikes have the potential to lower the wave load on the embankment. These areas may fulfill this flood protection function only when they can fully benefit from the hydrodynamic processes that ensure the supply of sediment and vegetation is able to develop without disturbances. Salt marshes reach their greatest extent along low-energy coasts where wave action is limited and mud can accumulate (Allen & Pye 1992). Temporary and limited disturbances in sedimentation processes within the coastal zone (including the salt marshes) will eventually be restored. For example, a moderate increase in sea level rise induces a greater accumulation on tidal flats and salt marshes as a result of longer tidal inundation (i.e. the sediment has more time to settle). As a result, the level of the flats and salt marshes increases and the period of tidal inundation decreases again, and the former dynamic equilibriumis restored (Hofstede et al. 2010).
EU Policies concerned and institutional process	WFD, Floods Directive, WS&D Policy; Nitrates Directive, Direct Payments; Rural Development Regulation; Birds & Habitats Directives; EU Biodiversity Action Plan; Biomass Action Plan; Proposal for a Soil Framework Directive. Buffer Strips are currently mandatory under the Common Agricultural Policy (cross compliance). However currently there is no common definition of a buffer strip and governments can apply their own rules. Hoewever under the Rural Development program payments are provided to extend such buffer zones. This can also include more wooden zone Salt marshes are also protected within the EU Habitats Directive. In addition, within the Water Framework Directive (WFD), salt marshes are considered as part of the quality element “angiosperms” which is one element to assess the ecological status of water bodies. The aim of the WFD is to achieve a good ecological status for all water bodies until 2015.In the framework of the Marine Strategy Framework Directive (MSFD), it has to be discussed at a later stage how salt-marsh habitat types can be incorporated to assess the good environmental status (Esselink et al. 2009). The role of salt marshes in spatial planning and coastal zone management is described in Hofstede et al. (2010).
Character of measure	Preventing
Sector(s) affected	Water managent, forestry, agriculture
Time to implement	Short term (5-25 yr), mid- to long term (25+ yr) Some effects in the short term (5-25 years), most important ones in mid to long term: >25 years.
Administration level	All three levels: National, Regional / River basin, Municipality / company.
Examples	Research suggests very high potential for controlling nitrogen pollutants (including nitrate), but performance is strongly dependent on characteristics such as buffer zone width, slope of the drained field, soil type and variety, and density of zone vegetation. Additionally, suspended solids and sediments (with absorbed pollutants such as phosphorus) are filtered and channel erosion is reduced; potential for protection against pesticides and heavy metals is also judged to be very high. Buffer strips also effect a reduction in pollution by changing

	land use (i.e. stopping agricultural activity in the buffer area).
Case studies	Buffer strips are being widely supported as agri-environmental measures in European rural development programmes, for instance in Spain; a typical value for buffer strips' width is around 5 m. Wider buffer strips, which provide additional protection but used to be considered too costly, are finding additional support: a new option of the English Environmental Stewardship programme supports 12 m wide buffer strips for watercourses on cultivated land.
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	and mitigation measures related with water. In: JRC Scientific and technical reports. O'Laughlin, J. & Belt, G.H. (1995) Functional approaches to riparian buffer strip design. Journal of Forestry, 93(2): 29–32. REFRESH. http://publications.jrc.ec.europa.eu/repository/handle/111111111/15801 Schrier-Uijl, A. (2010) Flushing meadows - The influence of management alternatives on greenhouse gas balance of fen meadow areas. In: Environmental Sciences, Wageningen: Wageningen University. Schrier-Uijl, A. P., Veraart, A. J., Leffelaar, P. A., Berendse, F. & Veenendaal, E. M. (2010) Release of CO2 and CH4 from lakes and drainage ditches in temperate wetlands. Biogeochemistry. van Beek, C. L., Pleijter, A. E., Jacobs, C. M. J., G.L., V., Van Groenigen, J. W. & Kuikman, P. J. (2010) Emissions of N2O from fertilized and grazed grassland on organic soil in relation to groundwater level. Nutrient Cycling in Agroecosystems 86(3): 331-340.
Related to REFRESH-Measure	M065/M397/M398/M067/M083

TRANSBOUNDARY FLOOD MANAGEMENT THROUGH SPATIAL PLANNING

Measure Number	SA09
Description	Transboundary flood management projects bring representatives together from regional and national authorities, water boards, and other organizations. The goal is to decrease the impacts of floods through good spatial planning.
Measure category	Support Action
Measure Sub-Category	Land use change and management
Climate threat	Too much water (flooding, sea level rise, coastal erosion) with consideration of enough water (scarcity & droughts),
Link to vulnerability	The measure reduces flood impacts(population and assets exposed, production affected) by decreasing the sensitivity (pressure) considering low flow impacts (navigation, biodiversity, agriculture, industry, drinking water) by decreasing the exposure (pressure) through good spatial planning.
Expert and stakeholder judgment	Subjected to a fast track assessment, the stakeholders assigned a high priority and urgency for the measure.
Qualitative assessment based on literature review	A large part of the world's freshwater resources is contained in river basins and groundwater systems that are shared by two or more countries. As climate change essentially changes the hydrological situation in many basins, increasing the number of extreme situations of flooding and drought, transboundary management of these water resources in order to prevent negative effects of unilateral adaptation measures and in order to choose the most effective measures has become highly urgent (Timmerman, Koeppel et al. 2011). In Europe, there exist 71 international river basins, accounting for 54% of the total area (Wolf, Natharius et al. 1999). It is estimated that European countries depend for more than 10% of their water resources on neighbouring countries and five countries draw 75% of their resources from upstream countries (UNECE 2005). International cooperation in river basins with respect to climate change adaptation is very important, as measures in one country could have negative effects in another or country-by-country measures could be less effective or more expensive than measures optimized over the full river basin (Van Pelt and Swart 2011). The basic difficulty in transboundary water management is that integrated water management in the whole river basin can only be achieved if neighbour countries, coming from different cultures, different political regimes and different levels of economic development effectively cooperate. Which means that in order to overcome this weakness, common river basin plans should be developed and approved by all the riparian countries (Mylopoulos, Kolokytha et al. 2008). The Flood Risk Directive is prescribing and stimulating cross border co-operation in warning

	systems and other elements of flood risk management. Consequently, we would expect an increase of cross border co-operation and collaboration in EU member states, through joint planning, co-management or co-implementation in flooding policies, water quality management or river rehabilitation. If we take a closer look at regional practices along member states' borders however, co-operation is often considered as problematic (Wiering, Verwijmeren et al. 2010). Several factors exist that will support or hinder cooperation between countries in transboundary water management. First, the characteristics of a given problem will influence the likelihood of successful cooperation; if the cooperation incentives are largely symmetric and the problem pressure is high, the prospects for effective cooperation are good. Second, cooperation between countries in collecting data and performing joint projects builds trust at the technical level and enhances cooperation on political levels. Thirdly, a clear institutional setting that is problem-oriented, flexible and equipped with a centralized organization structure enhances cooperation. (Joint bodies can be instrumental in this regard. Economic-technological capacities in the national water sectors as well as political stability are important factors for the development of joint water management). Finally, the international context is essential: if bilateral relations (characterized by mutual trust and cooperation), exist, effective transboundary water management will be possible (Lindemann 2006). In Europe transboundary management in several river basins have been researched. An example is the role of institutional design in the outcomes of water quality and ecology-related work carried out by the International Commission for the Protection of the Elbe (ICPE). Overall, this paper shows that the countries were relatively successful in achieving their overall goals. While the ICPE generally showed a high level of compliance, one main finding is that the ICPE's contribution towards achieving the goals varied significantly among the different areas of activity, and that much would also have been achieved in its absence The ICPE's contribution was greatest where the main responsibility for action lay with the public authorities, such as in the area of wastewater treatment and the establishment of an international alarm plan and model (Dombrowsky 2008).
EU Policies concerned and institutional process	Water Framework Directive, Flood Directive The EU policies throughout which the measure could be promoted include Water Framework Directive (WFD) and the Flood Directive (FD). The WFD introduces the notion of integrated water management in transboundary catchments and emphasizes the need for cooperation, for the establishment of common principles and for the coordination of actions to tackle with transboundary problems. The FD is prescribing and stimulating cross border co-operation in warning systems and other elements of flood risk management.
Character of measure	Preventing
Sector(s) affected	Water Management, Navigation
Time to implement	mid- to long term (25+ yr)
Administration level	National
Examples	The 1987 Rhine Action Program of the International Commission for the Protection of the

	Rhine (ICPR) with a number of success factors: 1. a joint vision; 2. a phased approach with achievable targets; 3. technical dialogue among those responsible for implementation; 4. implementation at the national level; 5. monitoring through publication of national reports; 6. admission of NGOs; 7. a small secretariat; 8. and the non-binding character of the action program (Dombrowsky 2008). The Nestos–Mesta example with possible success factors: 1. Interactive stakeholder involvement 2. common methodologies applied 3. broad public acceptance and support by key stakeholder groups 4. exchange of knowledge, experience, technology and know-how between the border countries (Mylopoulos, Kolokytha et al. 2008).
Case Studies	The ELLA project developed preventive flood management measures by transnational spatial planning for the Elbe River (shared mainly between the Czech Republic and Germany). The project brought partners together from regional and national authorities, water boards and some other organisations. The goal of this project is to decrease the impacts that floods can have by good spatial planning. Existing retention areas need to be protected and restored, and more retention in the precipitations area created; reduction of potential damage is important; and there is need for some technical flood protections measures. As part of the Ella project, hazard maps were drawn up for various sections of the river. In pilot projects, these maps where then integrated into the spatial planning.
Reference	Dombrowsky, I. (2008) Institutional design and regime effectiveness in transboundary river management? the Elbe water quality regime. Hydrology and Earth System Sciences **12**(1): 223-238. Lindemann, S. (2006) Water regime formation in Europe: A research framework with lessons from the Rhine and Elbe river basins, Forschungsstelle f. Umweltpolitik (ffu) Mylopoulos, Y., E. Kolokytha, et al. (2008) A combined methodology for transboundary river basin management in Europe. Application in the Nestos–Mesta Catchment Area. Water Resources Management **22**(8): 1101-1112. Timmerman, J. G., S. Koeppel, et al. (2011) Adaptation to Climate Change: Challenges for Transboundary Water Management. The Economic, Social and Political Elements of Climate Change: 523-541. UNECE (2005) About the UNECE water convention. http://www.unece.org/env/water/text/text.htm Van Pelt, S. C. and R. Swart (2011) Climate change risk management in transnational river basins: the Rhine. Water Resources Management (in press) Wiering, M., J. Verwijmeren, et al. (2010) Experiences in Regional Cross Border Co-operation in River Management. Comparing Three Cases at the Dutch–German Border. Water Resources Management: 1-26. Wolf, A. T., J. A. Natharius, et al. (1999) "International River basins of the world." International Journal of Water Resources Development **15**(4): 387-427.

LAND USE PLANNING

Measure Number	SA10
Description	Land use planning can be used in the case of droughts, scarcity and flooding and can significantly affect the hydrological cycle of a region. Land use planning can influence the water abstraction by a sector. Various measures, such as afforestation and sustaining wetlands, can reduce flood risk and make regions more resilient against droughts. Land use planning can also be used to reduce flood risks.
Measure category	Support Action
Measure sub-category	Land use change and management
Climate threat	All Climate threats
Link to vulnerability	How we use land affects our vulnerability to droughts and floods. In general, land use patterns that maintain the integrity of watersheds and that have a smaller water footprint result in greater resilience in the face of droughts. Regional land-use planning to provide space for rivers reduces a community's vulnerability to flood events and reduces damages.
Expert and stakeholder judgement	Subjected to a fast track assessment, the stakeholders assigned a high priority and urgency for the measures regarding land use planning.
Qualitative assessment based on literature review	Decision-making processes decide how land is used. Decision-making requires information on future use and the impact of climate change events. This scope includes informing choices on land-use change or improvements to land-use practices. Decisions need to address any potential and existing impacts of climate change on land use, on land condition and capability and on landscapes (Scottish Government, 2011). In assessing the effects of climate change on land use, the main challenges are seen to be increased flooding, coastal erosion, warmer temperatures and changing precipitation patterns and the consequences of these impacts for land use and spatial planning (ibid). Land use planning measures aim to reduce the damages associated with new developments in light of climate events. In many places the most valuable land resources in terms of soil fertility, urban development space, and infrastructure location are liable to flooding (WMP and GWP, 2008). Between 1998 and 2004, Europe suffered over 100 major damaging floods, including the catastrophic floods along the Danube and Elbe rivers in summer 2002. Severe floods in 2005 further reinforced the need for concerted action. Since 1998 floods in Europe have caused at least €25 billion in insured economic losses. There are two major aspects that connect land use and flooding (ibid): 1. The location of values and key components of the economy on flood plains provide economic benefits and potential losses. 2. The development of land impacts water flows by accelerating runoff due to soil

	sealing or obstructing natural drainage systems. Land use can be planned within a catchment to target the causes of flooding by distributing certain land uses in key areas. Land uses to be considered include vegetation cover, soil cover, river channels and other aspects such as ground drainage, access roads and river morphology (Johnson, R, 2008). For flooding, measures generally involve land use controls, such as zoning, and design characteristics for buildings such as minimum floor heights and water proofing (URS, 2002). Land use planning is also one of the main drivers of water use, and the inadequate water allocation between economic sectors in Europe has resulted in imbalances between water needs and existing water resources. A pragmatic shift is required in order to change policy-making patterns and to move forward effective land-use planning at the appropriate levels. When doing so it is required to discuss all different changes within the framework of multilevel territorial actors (e.g. agriculture, tourism) considering their different interests regarding water management (Dworak et al, 2009). Risks imposed on water services by drought must be taken into consideration in town planning and when granting individual building permits (Ministry of Agriculture and Forestry of Finland, 2005, p.199). Land use and spatial planning can, in theory, contribute to the protection of environmental resources and prevent the impacts of climate events (Carter, 2007): • Environmental problems associated with climate change must be considered over long time-periods and spatial scales. Long term land use/spatial planning can take into account these time and spatial concerns. • Land use plans take into account various sectors, such as housing, transportation, energy sectors, environment, and provides a framework for cooperation between national, regional and level levels. Three key mechanisms of spatial planning systems that are helpful in designing a more sustainable approach to the use and management of water are spatial plan preparation, development control and planning approaches and techniques (ibid). Land-use planning in areas prone to natural hazards such as snow avalanches focus on acceptable risks. In Switzerland, land-use planning for snow avalanches uses zoning to restrict building construction. Three zones are established: red where building in strictly prohibited, blue where building is possible but designs have to take impacts into account, and yellow with no restrictions. The use of maps and plans provide information regarding these restrictions and negative impacts are considerably avoided (Lateltin and Bonnard, 1999).
Costs	Planning measures can reduce the costs of flood risk by excluding some activities from the floodplain and by providing conditions under which particular development would be allowed at locations with given flood risk. Previous work in Australia, for example, has suggested that land use planning is one of the most cost-effective means of reducing the growth of future flood damage in Australian (URS, 2002); studies undertaken in the 1990s evaluated the benefits of planning measures in state of Victoria and found that introducing long-terming planning measures could have benefits-cost ratios in the order of 2.0 to 3.8 (ibid, p. 3-1). In the UK, demonstration sites introducing natural water retention by land use management have shown significant reductions in flood risk (Johnson, 2008). Land use planning and concentrating construction outside flood risk areas are the cheapest ways to avoid flood damage (Ministry of Agriculture and Forestry of Finland, 2005, p.199).
EU Policies	Land use planning also impacts the CAP, Birds and Habitats Directives, the Floods Directive,

concerned and institutional process	Energy policy the Strategic Environmental Impact Assessment Directives. The implementation of the WFD impacts many sectors ranging from agriculture and forestry to water services and spatial planning. The successful achievement of the WFD's goals will ultimately depend on the effective integration of land and water management processes. As such, planning authorities play a key role in WFD implementation through ensuring that the development and land use is in line with WFD requirements. Spatial planning procedures can contribute directly to some of the 'basic measures' outlined in Article 11: through the preparation of spatial plans, development control, and the application of planning techniques and approaches, spatial planning can contribute to the successful implementation of the WFD's 'basic measures' and can consequently help to encourage the sustainable management and protection of freshwater resources. Special planning is also an important tool to deal with conflicting policy targets set out in EU agricultural, transport, energy and environmental planning.
Character of measure	Preventing, Preparatory
Sector(s) affected	Water, agriculture, energy, industry, forestry and domestic/tourism
Time	Short term (5-25 years)
Admin level	National/Regional
Reference	Carter, J (2007) Spatial planning, water and the Water Framework Directive: insights from theory and practice. Geographical Journal. http://findarticles.com/p/articles/mi_go2454/is_4_173/ai_n29412072/. Dworak, et al (2009) Scenarios of Water Demand Management. Impacts at regional level (summary). Johnson, R. (2008) The role of catchment land use planning flood risk management. Paper presented at a Workshop on Flood Management in Local Planning, Austria/Slovenia, 8-10 April 2008. http://www.clim-atic.org/documents/Land%20use%20planning.pdf Lateltin, O and Bonnard, C. (1999) Hazard assessment and land-use planning in Switzerland for snow avalanches, floods and landslides, in WMO (eds.) The Comprehensive Risk Assessment for Natural Hazards – A contribution to the International decade for natural disasters reduction. http://www.eird.org/deslizamientos/pdf/eng/doc12082/doc12082-contenido.pdf Ministry of Agriculture and Forestry of Finland (2005) Finland's National Strategy for Adaptation to Climate Change. http://www.mmm.fi/attachments/ymparisto/5kghLfz0d/MMMjulkaisu2005_1a.pdf Scottish Government (2011) Scotland's Climate Change Adaptation Framework. Spatial Planning and Land Use Sector Action Plan. http://www.scotland.gov.uk/Resource/Doc/175776/0114928.pdf URS (2002) Economic Benefits of Land Use Planning in Flood Management. http://www.water.vic.gov.au/__data/assets/pdf_file/0017/15263/Econ-Benefits-of-Land-Use-Planning-Flood.pdf WMO and GWP (2007) The role of land-use planning in flood management. http://www.apfm.info/pdf/ifm_tools/Tools_The_Role_of_Land_Use_Planning_in_FM.pdf

Related to REFRESH-Measure	Relates to almost all measures but in particular to M017,M018, M019, M020, M021, M022, M023, M024, M025, M026, M027, M028, M029, M030, M031, M032, M033, M034, M035, M036, M037, M038, M039, M045, M046, M047, M048, M049, M050, M051, M052, M053, M054, M055, M056, M057, M058, M059, M060, M061, M062, M063, M064, M119, M120, M125, M129, M202, M203, M204, M205, M318, M324, M378, M379

ADAPTATION EXISTING DIKES

Measure Number	M08
Description	The design of existing dikes can be modified to fulfil different purposes. Re-enforcing dikes and dams can increase their stability and resistance against dike breaching, e.g. by strengthening the inner core of the dike, or improving characteristics of the dike's surface that contribute to the overall stability of the dike. Dikes can also be re-enforced by heightening, broadening or by adding spatial components. Dike design can have the aim of allowing water in certain conditions to overtop them without breaching. This is usually achieved by strengthening the inner wall of the dike and by dike broadening. Surplus water will be pumped away. Reallocation of dikes (spacing) will create a wider floodplain with enclosed retention area.
Measure category	Measure
Measure sub-category	Technical measure related to technical infrastructure
Climate threat	Too much water (flooding, sea level rise, coastal erosion).
Link to vulnerability	These measures reduce flood risk for the people and assets in the affected area, by decrease of the sensitivity state through strengthening, improving and reallocation of the dikes to resist and decrease high water levels.
Expert and stakeholder judgement	Dike reinforcement has strong supporters and opponents. Support is typically strong after a flood event. Where reinforcement is planned to pro-actively adapt to climate change it is more likely to meet resistance. Heightening and reinforcement of dikes can affect the landscape in a negative way. In countries like the Netherlands, people started to resist reinforcement programmes. The loss of historic houses and views are perceived as most problematic. In addition, raising dike height can increase water levels in the river during high flow. In response, various alternatives to dike reinforcement have been developed, including widening the riparian areas and floodplain, creating overflow channels and lateral diversions do increase the capacity of rivers. As for “Overtopping resistant dikes”, which ,may be more costly, has a typical time horizon of 50 years when used in the economic assessment. For a longer time horizon and including maintenance, the comparison becomes more favourable. At the same time, the overtopping resistant dike can be combined with other functions, raising its multi-functional character and broadening opportunities for financing. Opportunities for this are location specific. Challenging the overtopping resistant dike has no set dimensions or form, though it does tend to be wider and less steep than traditional dikes and include a protection zone parallel to existing flood defences. Thus one of the complexities involved in developing overtopping resistant dikes is to create and secure more space. In addition, as a consequence of wave overtopping under extreme conditions, the multifunctional coastal zone should be made adaptive to occasional accommodation of salt water in that area. Such a spatial adaptation may offer opportunities for salt or brackish ecosystems, recreation, living and wet agriculture.

To give designers and managers of flood defences more opportunity to develop overtopping resistant dikes, typically modifications are required in current design guidelines and technical prerequisites. Current law and legislation have been developed with the more traditional dike concept in mind, e.g. the appraisal of the probability of flooding versus the risk of a dike break in the overall dike evaluation have to be re-evaluated.

The measure was evaluated in the short track assessment of the CWA workshop with a middle urgency and priority, because the situation is very different in different Eruopean regions.

Qualitative assessment based on literature review

The following qualitative assessment based on literature review concerns “Re-enforcement of dikes and dams” measure.

Projections of more frequent extreme water levels and storms may call for dike re-enforcement, especially if the safety standards for dikes are based on climate scenarios. Dikes can be re-enforced by heightening, broadening or by adding spatial components. Heightening is the usual way to re-enforce dikes. Heightening provides coastal defence, but without integrated development or a combination of functions that a spatial solution may offer. Broadening may also offer additional benefits, yet may not be practicable because space is limited or for socio-economic reasons. If re-enforcing the flood defence system becomes necessary due to climate change, recent studies advocate a three steps approach, considering 1/ spacing, 2/ broadening and 3/ raising consecutively.

As to “Overtopping resistant dikes”, where climate change will cause on-going sea level rise and increased wave attack at the primary coastal and riverine defences. This development requires an adequate response, e.g. traditionally by increase of the height of the primary defences and adaptation of the slopes. As an alternative, overtopping-resistant dikes may be applied. The overtopping dike can provide more safety against flooding than the typical single-line defences. As the dike will not breach when overtopped, the dike prevents the uncontrolled catastrophic dike breaks associated with devastating flooding of the hinterland. The number of potential victims and the resulting damage are therefore much lower than incurred when a traditional dike breaks. The risk, calculated as a product of the probability of occurrence and the resulting damage, is thus reduced. Overtopping can still result in anxiety and minor damages. These can be reduced by spatial planning or subject to compensation and insurance schemes.

Costs

Experience with dike re-enforcement in the Netherlands has yielded the following indicative estimates of total cost:

Dike level	Costs [million euro / km]
low river dike	3
high river dike	5
estuarine dike	5
coastal defence	7,5

In respect to “Overtopping resistant dikes”, yielded the following indicative cost estimate. The approach was found to be particularly cost-efficient of lake and river dikes.

Water system	Costs [million euro / km]
Sea	3.3
Estuaries	3.9

Lakes	1.1
Rivers close to river mouth	3.3
Upland rivers	1.9

EU Policies concerned and institutional process	Cohesion policy, Floods Directive This measure can only be supported under the EU cohesion policy. However it should be seen as the second best option after giving rivers more space (see Factsheet 12). Any changes to existing dike systems have to in line withe the WFD requirements.
Character of measure	Preventing
Sector(s) affected	Water Management.
Time to implement	Short and long term (25+ yr).
Administration level	National, regional and river basins
Examples	Dike adaptation can be realized by: 1. heightening of dikes 2. reinforcement of dikes and 3. 4. Overtopping of resistant dikes, 5. widening the riparian areas and floodplain.
Case studies	Strengthing the Hondsbossche and Pettemer sea defences (NL) - A section of dike in North Holland no longer meets the legal safety requirements. Four alternative designs have been drawn up and subjected to an environmental impact statement. A decision-making process, is taking place; the overtopping dike has been selected as one of the preferred measures. (http://ec.europa.eu/ourcoast/index.cfm?menuID=4&articleID=121) The Broadland Flood Alleviation Project is a long-term project to provide a range of flood defence improvements, maintenance and emergency response services within the tidal areas of the Rivers Yare, Bure, Waveney and their tributaries. The land has high environmental value and is important to the local economy through its use for farming and tourism (http://ec.europa.eu/ourcoast/index.cfm?menuID=4&articleID=83). Renaturation of the Langeoog Summer-Polder (DE) Construction of a paved, overtopping-resistant road dam for pedestrians, cyclists and vehicles in the middle of the island to create access to the youth hostel, gastronomy and the eastern end of the island and provide water management and erosion protection functions (CPSL). The Overdiepse Polder is one of the places where the river will be given more space. A new primary dike will be built along the Oude Maasje river. Farms will be rebuilt on artificial hills and the current dike on the north side will be lowered and ready for overtopping at high river discharges. http://www.brabantsedelta.nl/overdiep/english/the_overdiepse.
Reference	ComCoast (2007) ComCoast flood risk management schemes, EU-Interreg IIIb North Sea Programme ComCoast WP 3. http://www.comcoast.org/pdfs/technicalsolutions/Comcoast_%20Flood_risk_managment_schemes.pdf CPSL THIRD REPORT The role of spatial planning and sediment in coastal risk management, http://www.waddensea-secretariat.org/management/cpsl/CPSL%20third%20report.pdf de Moel, H., Beijersbergen, J., van den Berg, F., de Goei, J., de Koch, R.C., Koelewijn, A.R., van Loon-Steensma, J.M., Molenaar, I.M., Steenbergen-Kajabová, J., Schelfhout, H., Versluis,

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Dike improvement Lek/Betuwe/Tieler- en Culemborgerwaard: Jeannette Bos, communicatieadviseur Waterschap Rivierenland, e-mail: j.bos@wsrl.nl, telefoonnummer 0344-649819, http://www.ruimtevoorderivier.nl/waar-doen-we-dit/projecten/gelderland/dijkverbetering-lek--betuwe--tieler--en-culemborgerwaarden REFRESH: http://publications.jrc.ec.europa.eu/repository/handle/111111111/15801

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SOFT COASTAL DEFENSES

Measure Number	M09
Description	A new paradigm of giving space to water and using natural landscapes to aid coastal defense infrastructure is emerging. Example measures are: • Allowing the sea to invade former dune slacks in certain sections of the coast. • The strategic construction of reefs along a coastline is likely to reduce the strength of waves, and thus the erosion of the coastline by the sea. • Applying sand suppletion to maintain the amount of sand present in the "foundation" of the coast (beaches and underwater in the shallow bank zone). • Managed retreat of coastal defenses. • Widening protection structures instead of making them higher and stronger  Introduction figure on alternatives for traditional coastal defense engineering solutions. (source: http://www.comcoast.org/)
Measure category	Measure
Measure sub-category	Technical measure related to technical infrastructure
Climate threat	Too much water (flooding, sea level rise, coastal erosion)
Link to vulnerability	The measure reduces flood risk (people and assets flooded) by decreasing state of sensitivity through natural solutions at the coast line

Expert and stakeholder judgment

Via a short track assessment stakeholders evaluated the measure with a high urgency and priority.

Qualitative assessment based on literature review

Much literature exists on the intention to adapt coastal defenses with ‘soft engineering measures’. Little or no literature present results, impacts and cost benefits yet and a few papers present model results.

The DHV report presents some hard data on plans and actual practices restricted to five North Sea countries. The table presents an overview of flood defense measures in five countries.

Table 3. Flexibility of existing defence systems

Country	Physical Measures	Flexible defence	Measures with view on climate change
Be	Sand nourishments, sea dikes	Annual monitoring and review every 5 year.	Additional sand nourishment
Dk	Sea dikes, sand nourishments at few locations	Routine inspections, maintenance when needed on managed coasts	Additional sand nourishment, dike reinforcements
Nl	Sand nourishments, dikes, storm surge barriers	Routine raising of defence structures with 5 year review period, yearly coastline monitoring, 50m inland zone reserved (200yr sea level rise)	Additional sand nourishment, reinforcement 10 weak links, possible seaward extensions
Ge (NS)	Foreshore maintenance, Closing rivers, Sea dikes	50m inland zone reserved; Defences designed for raising 1 m max	None
Ge (SH)	Sea dikes Sand nourishment Foreland maintenance	Routine raising of defence structures with 10 year review period	Additional value for sea level rise in dike heights
UK	Sea walls, beach management, limited realignment, surge barrier	Routine programmes of cost-benefit and risk-based monitoring, beach management, shoreline management plans	Adaptive measures recommended for strategic planning of defences

The Dutch innovation program ‘Building with Nature’ (see www.ecoshape.nl and De Vriend 2011) is starting to produce research results on design principles, impacts, governance aspects and cost-benefits of ecodynamic designs of coastal infrastructure. The program aims to take advantage of the opportunities offered by water and sediment currents. It promotes coastal management solutions that reconcile the needs of society and the concerns for the environment with the growing societal demand for welfare and well-being. An integrated ecosystem-based approach and stakeholder involvement from the early stages of project development onwards are essential features. This ecosystem-based approach, boils down to:

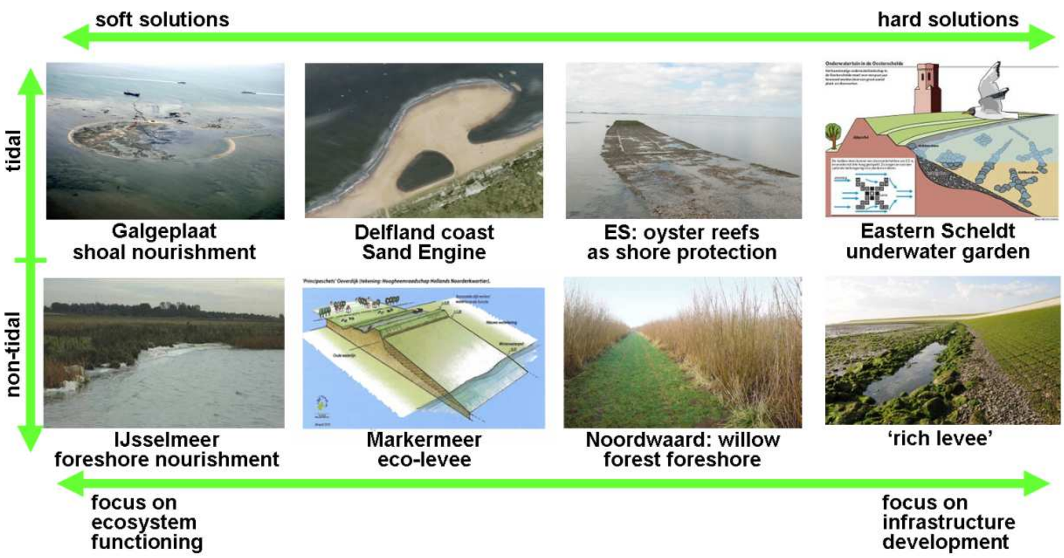
1. Understand system functioning ('read' the ecosystem, the socio-economic system and the governance system),
2. plan a project or activity taking the system's present and envisaged functions into account (combining functional and ecological specifications),
3. determine how natural processes can be used and stimulated to achieve the project goals and others (using the power of nature),
4. determine how governance processes can be used and stimulated to achieve the project goals (using the power structures in place),

5. monitor the environment during execution, analyze the results statistically, make risk-assessments and - if necessary - adapt the monitoring program and/or the project execution (monitoring and adaptive management), and

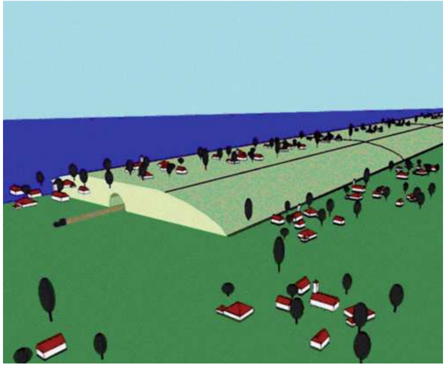
6. monitor the environment after completion, as to assess the project's performance and to learn for the future (experience harvesting, knowledge development) and, if necessary, to adjust the project design.

The figure positions alternatives to traditional hard coastal engineering. See also the Klimzug Standort project in Germany (http://www.klimzug.de/en/index.php) and Waterman 2008.

Figure: positioning of ecodynamic design (source: De Vriend, 2011)



New designs and ideas are under development. An example is the idea of 'climate dikes'; widen protection structures rather than make them higher and stronger. This widening could amount up to 300 m inward and could give the possibility to use the space the dikes provide for new functions, like agriculture, recreation, but also residential areas could be situated on top of the dike. In order to create such an elevated band along the coastline, it would be necessary to 'lift up' existing economic activity and housing. However, financially it turns out that conventional reinforcing dikes is more expensive in maintenance than this idea (source: http://icm.eionet.europa.eu/ETC_Reports/Good_practice_report_final_ETC.pdf).

	 Figure Climate dike (source: Velinga et. al.) Side effects of soft coastal defenses are usually part of the design, as designs are multi functional. These kind of measures combine flood defenses with functions like: nature development, recreational and tourism development and even with urban planning. The aim is to get to win - win situations in terms of sharing the costs of the new infrastructure, but also in sharing of the benefits. A negative side effect is the extra space needed (see DHV). In heavily populated areas (and coastal zones and delta's usually are) space is expensive and competing claims on the use of space exist. Governments advocating soft coastal defenses must therefore compete with other land users. A side effect is that the realization of soft coastal defenses asks for long and complex procedures and negotiations. The dike also can be constructed in sea-wards direction. The performance under flexibility and the robustness are considered main advantages of soft coastal defenses. An example is sand nourishment before the coast of the Netherlands, with the objective to prevent erosion and maintain the beaches and dunes. The quantity and the frequency of nourishments can be adapted year to year, depending on local needs (for instance after storm damages) and sea level rise. (See Delta Commission 2008) The use of bioengineers (like oyster and coral reefs and wetland protections) is also adaptable to changing conditions. Experts claim that the cost benefit ratio of this type of measures is better than that of traditional coastal defenses. But this claim is not substantiated by independent evaluations and researches yet. The conditions for decision making are favorable for measures like sand nourishment, because these are standing practice already for a few decades. But more innovative measures (reefs, retreats) are not without problems, because of claims on land or lack of evidence and uncertainties on potential effects on security. Also existing regulations may hamper implementation. A much used example is the EU Natura 2000 regulations, requiring maintenance of existing habitats and species, thus hindering proposals for changes along the coast.
EU Policies concerned and institutional process	Marine Strategy Directive; Floods Directive; Council Reg (EC) N° 1083/2006 The aim of the European Union's ambitious Marine Strategy Framework is to protect more effectively the marine environment across Europe. The objective is to achieve good environmental status of the EU's marine waters by 2020. The Marine Strategy has a special focus on climate change. Under the Marine Strategy every Member State has to develop a programme of measures with which a good environmental status can be reached or kept. The European Parliament and the Council adopted in 2002 a Recommendation on Integrated Coastal Zone Management (ICZM). The Recommendation includes the principles

	of sound coastal planning and management. It outlines steps which the Member States should take to develop national strategies for ICZM, based on common ICZM principles. At the moment the ICZM Recommendation is under review. 2008, the European Commission established the OURCOAST initiative which has the objective to ensure that lessons learned from the coastal management experiences and practices will be shared and made accessible to those who are seeking sustainable solutions to their coastal management practices. OURCOAST has a focus on adaptation to risks and the impacts of climate change. EU Flood Directive addresses also coastal floods and measures have to be included in the flood risk management plans.
Character of measure	Preventing
Sector(s) affected	Water Management, domestic/ tourism
Time to implement	mid- to long term (25+ yr)
Administration level	National, Regional, Municipality, company
Examples	Examples of measures for more space to water and using natural landscapes to aid coastal defense are: - Allowing the sea to invade former dune slacks in certain sections of the coast. - The strategic construction of reefs along a coastline is likely to reduce the strength of waves, and thus the erosion of the coastline by the sea. - Applying sand suppletion to maintain the amount of sand present in the "foundation" of the coast (beaches and underwater in the shallow bank zone). - Managed retreat of coastal defenses. - Widening protection structures instead of making them higher and stronger
Cases	Some projects in the 'Building with nature' programme in The Netherlands
Reference	ComCoast W3. Flood risk management schemes.EU-Interreg IIIb North Sea Programme 2007. http://www.comcoast.org/pdfs/technicalsolutions/Comcoast_%20Flood_risk_management_schemes.pdf De Vriend H. (2011) Biogeomorphology: why? Paper at the 7th IAHR Symposium on River, Coastal and Estuarine Morphodynamics (RCEM) Delta Commission (2008) Working together with water. A living land builds for its future Findings of the Dutch Deltacommissie. The Hague, Netherlands. http://www.deltacommissie.com/doc/deltareport_full.pdf DHV (2007) SAFECOAST: Quick Scan Climate Change Adaptation, With a focus on coastal defence policies in five North Sea countries. Dutch Ministry of Transport, Public Works and Water Management, National Institute for Coastal and Marine Management. http://www.safecoast.org/editor/databank/File/DHV%20QS%20Climate%20Adaptation.pdf Ecologic (2009) Report on good practice measures for climate change adaptation in river basin management plans. http://icm.eionet.europa.eu/ETC_Reports/Good_practice_report_final_ETC.pdf

	Global Climate Change and Adaptation – A Sea-Level Rise Risk Assessment. Prepared For: The City of Cape Town, Environmental Resource Management Department,2008 http://www.capetown.gov.za/en/EnvironmentalResourceManagement/publications/Documents/Phase%204%20-%20SLRRA%20Adaptation+Risk%20Mitigation%20.pdf SMEC Australia (2007) Climate change adaptation actions for local government. Report to the Australian Greenhouse Office, Department of the Environment and Water Resources www.hunterlandcare.org.au/.../climate-change/Climate_change_adaption_actions_for_local_governme.pdf Vellinga P. Marinova N. van Loon-Steensma J.M. (2009) Climate-proofing the flood protection of the Netherlands. Netherlands . Journal of Geosciences 88 – 1 p. 3 – 12 Waterman R.E. (2008) Integrated coastal policy via Building with Nature. Opmeer Drukkerij bv, Den Haag, 449 pp. Zedler J.B. (ed.) (2001) Handbook for restoring tidal wetlands. Marine Science Series, CRC Press, Boca Raton, 439 pp. Report on good practice measures for climate change adaptation in river basin management plans. http://icm.eionet.europa.eu/ETC_Reports/Good_practice_report_final_ETC.pdf
Relate to REFRESH Measures	M367/M126/M121/M365

SAFE HAVENS IN INLAND WATERS AND ADDITIONAL TEMPORARY MOORINGS

Measure Number	M10
Description	Alter existing havens or construct new ones to address safety issues for increased frequency of strong stream conditions, floods and low water levels. Additional moorings address safety issues of increased frequency from strong stream conditions as a result of high water levels or for periods with low precipitation and low water levels.
Measure category	Technical Measure
Measure sub-category	Technical measure related to technical infrastructure
Climate threat	Not enough water (scarcity & droughts), Too much water (flooding, sea level rise, coastal erosion)
Link to vulnerability	Addresses impact indicator lossess due to flooding via state indicator land use changes (spatial planning) The measure reduces the vulnerability of shipment and freight transport against extreme water levels resulting from extreme precipitation (low and high). The measure directly influences the navigation and transport sectors.
Expert and stakeholder judgement	For this measure no evaluation was conducted.
Qualitative assessment based on literature review	Literature sources on climate impact on havens describe a higher intensity and number of periods with low water level due to low run-off in times of droughts. Another effect is increased water levels in rivers which will occur as a result of higher intensity and quantity of rainfall and resulting flooding. Additionally, for marine seaports, rising sea levels and intensity of extreme storms and storm floods are problematic. This may allow greater penetration of wave energy to the coastline and into harbours, causing increased coastal erosion in areas with a soft coastline. The capacity of port drainage systems can be overwhelmed by extreme precipitation, leading to surface flooding. For those ports with drainage outlets discharging to a water body, increased water levels can further reduce drainage capacity: if water levels on docks and harbours rise above the level of drainage outlets, drainage pipes can be surcharged and the flow through them can be reduced (i.e. Hawkes et al 2010, Swedish Commission on Climate and Vulnerability 2007, Stenek 2011, Defra 2011). To address these problems, responses must adapt harbor infrastructure by securing harbour walls and other harbour infrastructure, for example by securing against storms, dealing with increased corrosion rates and degradation of materials over time, adapting moorings in ports to changing water levels, install additional moorings in and outside of harbours where ships can be kept during floods and low water levels. These facilities will need to have safe access to shore and facilities for crews. More storage capacity at cargo terminals is required for use in times of closure. The adaptation of drainage systems may be

	necessary, depending on the local situation and the currently installed system (Grothman et al 2009, BMVBS 2009, Firth & Colley 2006, Hawkes et al 2010). Negative effects can be seen in combination with land use for other users. For further mooring areas in and outside of harbours and more storage possibilities land is needed close to the existing harbour area. Additionally, areas close to harbours cannot be used because of a high risk of flooding. This is a regret-measure which shows low potential for win-win situations with other current developments. (PIANC 2008, IWAC 2009)
Costs	As a barrier for implementation of additional mooring and safe havens, IWAC (2009) point out the costs for these measures. Some extra investment costs arise from the measure, such as establishing more moorings and adapting buildings and units. These investments should be included in regular investment cycles. Other aspects of the measure, like defense against corrosion will lead to higher maintenance costs every year. Because of a more secure port infrastructure freight shipment will have higher security which is highly important to industry as client of ship transport. Therefore benefits can be found for the transportation sector and lower costs for freight transportation on waterways for industrial companies. Social costs occur through higher land use near harbours if infrastructure has to be relocated or additional moorings are necessary. Higher competition for remaining land, which is not impacted by flooding, is expected. Through further land use consequences for wildlife and biodiversity can also be assumed. (PIANC 2008, IWAC 2009)
EU Policies concerned and institutional process	Trans-European transport network (TEN-T) programme, the European Cohesion Fund and the European Regional Development Fund, Water Framework Directive, Flood Directive Marine Strategy Framework Directive, Integrated Coastal Zone Management The EU policies throughout which the measure could be promoted include, trans-European transport network (TEN-T) programme, the European Cohesion Fund and the European Regional Development Fund. The objective of the TEN-T is to establish an efficient trans-European transport network (TEN-T) and to increase the sustainable mobility of persons and goods across the EU. TEN-T points out that climate change objectives should be placed at the centre of future TEN-T policy. The vulnerability of the TEN-T to climate change and potential adaptation measures should therefore be assessed, and attention should be given to the question of how to "climate proof" new infrastructure. (Commission of the European Communities 2009) TEN-T implementation is also supported by the European Cohesion Fund and the European Regional Development Fund. The WFD requires ports (as heavily modified water-body/HMWB) to achieve good ecological potential by 2015 via River basin management plans. The Marine Strategy Framework Directive has the objective to reach a good environmental status in European Seas. Efficient drainage systems, also for flooding, could be promoted through the WFD and the MSFD. EU Flood Directive: Areas of ports are included the Flood Risk Management Plans. Havens at the coast are part of the coastal zone and have to be included in an integrated coastal zone management. The Recommendation on Integrated Coastal Zone Management (ICZM) from 2002 includes principles of sustainable sound coastal planning and management.
Character of measure	Preparatory, Reactive
Sector(s) affected	Navigation, Water management
Time to	Short term (5-25 yr)

implement	
Administration level	Regional / River basin, National
Reference	BMVBS (2009) Tagungsband: KLIWAS: Auswirkungen des Klimawandels auf Wasserstraßenund Schifffahrt in Deutschland. German Federal Ministry of Transport, Building and Urban Development, Bonn. Commission of the European Communities (2009) Green Paper: TEN-T: A policy review. Towards a better integrated Transeuropean Transport Network the Service of the common Transport Policy. COM(2009) 44 final. Defra (2011) Climate Resilient Infrastructure: Preparing for a Changing Climate. London. Firth, J. & Colley, M (2006) The Adaptation Tipping Point: Are UK Businesses Climate Proof? Acclimatise and UKCIP, Oxford. Grothman, T. et al (2009) KYOTOPLUS-NAVIGATOR. Praxisleitfaden zur Förderung von Klimaschutz und Anpassung an den Klimawandel – Erfolgsfaktoren, Instrumente, Strategie. www.erklim.de. Hawkes, P. et al (2010) Waterborne Transport, ports and navigation: Climate change drivers, impacts and mitigation. PIANC MMX Congress Liverpool UK 2010. IWAC (2009) Climate change mitigation and adaptation: Implications for inland waterways in England and Wales. London. PIANC (2008) Waterborne transport, ports and waterways: a review of climate change drivers, impacts, responses and mitigation. EnviCom Task Group 3 report. Brussels. http://www.pianc.org/downloads/envicom/envicom-free-tg3.pdf Stenek, V. (2011) Climate Risk and Business: Ports. International Finance Corporation (ICF), Washington DC. Swedish Commission on Climate and Vulnerability (2007) Sweden facing climate change: threats and opportunities. Stockholm.

LEAKAGE CONTROL IN WATER DISTRIBUTION SYSTEMS

Measure number	M11
Description	Controlling water leakage from extensive and aging municipal and agricultural water distribution systems.
Measure category	measure
Measure sub category	Technical measure related to technical infrastructure
Climate threat	Water scarcity and drought
Link to vulnerability	This measure addresses Water stress impact/vulnerability indicator via the state indicator Water use and Water use efficiency sensitivity pressure indicator
Expert and stakeholder judgement	Subjected to a fast track assessment, the stakeholders assigned a high priority and urgency for the measure.
Qualitative assessment based on literature review	Despite the rapid developments in the water industry, water loss via leakage is still one of the main challenges in both municipal and agricultural water distribution systems (e.g. Giustolisi et al. 2008, Ecologic et al. 2007, Perez et al. 2010). The EU Water Saving Potential Report concludes that in regard to public water supply (including households, public sector, and small businesses), there is a high potential to reduce leakage in water supply networks. Combined with water saving devices and more efficient household appliances, it is estimated that public water supply can save up to 50% on the consumption side. Hence, understanding the circumstances under which leakage in distribution occurs is a crucial factor towards establishing resource saving infrastructures. Pressure, among other factors, is a fundamental aspect of a leakage avoidance strategy (Lambert 2000, Obradovic 2007). Minimum night flows in urban water distribution networks cause a higher leakage because the pressures in the network are usually higher at night than during the daytime. Promising approaches for reducing water loss due to leakage are localization methods of leakage based on pressure sensitivity analysis and automatic pressure control using new management practices. Perez et al. 2010 suggest a leakage quantification and localisation methods based on the pressure measurements and pressure sensitivity analysis of nodes in networks using pressure sensors. Other research is focusing on automatic pressure control. By using state of the art hydraulic network analysis, Araujo et al. 2006 show a practical and efficient solution for pressure management.
EU Policies concerned and institutional process	Urban Waste water The EU policy which could promote the measure is the urban waste water directive. The directive should ensure inter alia that the environment is protected from adverse effects of the discharge of wastewater including urban waste water treatment.

Character of measure	Preparatory, Recovery
Sector(s) affected	Water management, Agriculture, Domestic / Tourism, other sectors indirectly
Time	Short term (5-25 yr)
Admin level	Regional, Municipality/company
Reference	Araujo, L. S., Ramos, H. and Coelho, S. T. (2006) Pressure Control for Leakage Minimisation in Water Distribution Systems Management. *Water Resources Management* **20** (1): 133-149. Ecologic, ACTeon, National Technical University of Athens (NTUA), Universidad de Córdoba (2007) EU Water saving potential (Part 1 –Report). ENV.D.2/ETU/2007/0001r. 246. Giustolisi, O.; Savic, D. and Kapelan, Z. (2008) Pressure-Driven Demand and Leakage Simulation for Water Distribution Networks. *Journal of Hydraulic Engineering* **134** (5): 626. Lambert, A. (2000) What do we know about pressure leakage relationships in distribution systems? IWA Brno 2000. http://www.studiomarcofantozzi.it/BRNOP4.1.pdf Obradovic, D. (2000) Modelling of demand and losses in real-life water distribution systems. *Urban Water* **2** (2): 131-139. Orazio, G.; Dragan,S., and Zoran, K. (2008) Pressure-Driven Demand and Leakage Simulation for Water Distribution Networks. *Journal of Hydraulic Engineering* **134** (5): 626. Pérez, R.; Puig, V.; Pascual, J.; Quevedo, J.; Landerosc, E.; Peralta, A. (2011) Methodology for leakage isolation using pressure sensitivity analysis in water distribution networks, *Control Engineering Practice* In Press.
Related to REFRESH Measure	M306

ENHANCING OR INCREASING WATER STORAGE CAPACITY OF RESERVOIRS

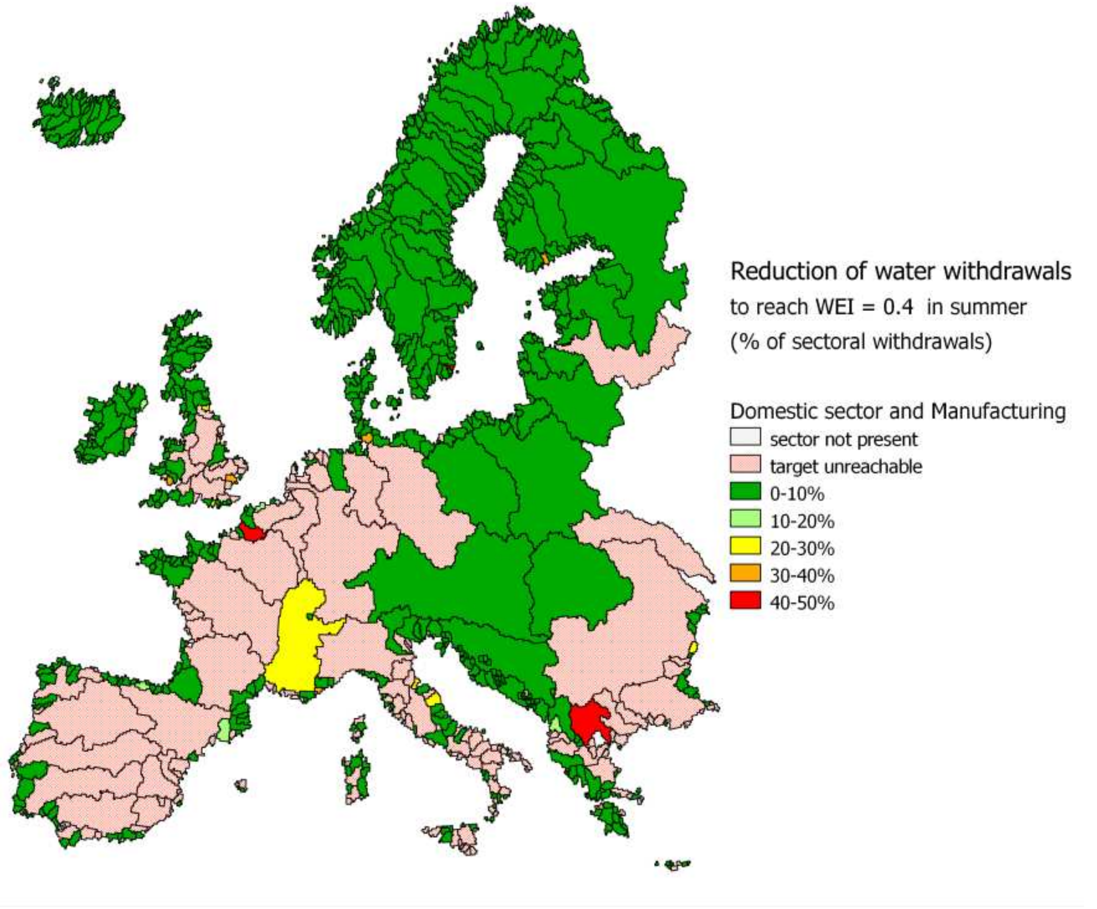
Measure number	M12
Description	Reservoirs can contribute to redistributing available water resources in volume, time and space. Water that is stored during high flows can be distributed in dry periods to supply water for additional irrigation, and can make a region less vulnerable for droughts. At the same time, large reservoirs that have the capacity to store part of the high flows and release it during lower flow periods, reduce peak flows and can prevent a region from flooding.
Measure category	Measure
Measure sub-category	Technical measure related to technical infrastructure
Climate threat	Not enough water (scarcity & droughts), too much water (flooding)
Link to vulnerability	The measure reduces the impact (people and area affected) of climate events (droughts and floods) by decreasing the exposure pressures on water availability (for droughts) and water excess (for floods) through the storage capacity of reservoirs.
Expert and stakeholder judgement	This measure is identified as being of EU relevancy, as it is explicitly recommended in the EU CIS guidance "River Basins Management in a changing climate". A multi-criteria analysis with input from stakeholders and experts (CSER 2011), stakeholders express the following remarks/uncertainties: ▪ There might be quite large negative side effects, mainly on the environment and nature. ▪ The effectiveness of a dam is very depending on the management of it and can therefore be very different from project to project. ▪ The safety of the reservoir structure can be a high risk factor ▪ Soil and water conservation in the watershed will increase the duration of an efficient use ▪ Time frame: it needs a very long time planning before the structure is in place. ▪ The performance under uncertainty is low. ▪ Urgency and priority is stated as high.
Qualitative assessment based on literature review	Reservoirs were built for multiple purposes: to use the energy potential of rivers for electricity production, to reduce discharge variability for improved navigation or flood control, or to supply water for irrigation and other users [ICOLD, 2007; WCD, 2000]. Nilsson et al. [2005] showed that currently over half of the world's global river systems are regulated by dams, which mostly lie in basins where irrigation and economic activities take place. For African countries, a correlation has been found between the storage capacity of the country and its economic development [Ludwig, et al., 2009]. In addition to the positive effects that large infrastructural water project like dams can have on water supply for different sectors and on flood risk reduction, there are also negative effects. These negative effects include alteration of the natural river dynamics of water,

	sediments and nutrients, habitat fragmentation and loss of biodiversity [Graf, 2006; Poff, et al., 2007; Rosenberg, et al., 2000; Syvitski, et al., 2005; Vörösmarty, et al., 2003]. Biemans et al. (2011) estimated the total global annual water withdrawals for irrigation from large reservoirs to be around 460 km3. Basins that rely heavily on reservoir water are the Colorado and Columbia basins and several large basins in India, China and Central Asia (e.g. in the Krishna and Huang He, reservoirs more than doubled surface water supply). Continents gaining the most are North America, Africa and Asia.
EU Policies concerned and institutional process	Water Framework Directive, Communication on water scarcity and droughts, SEA Directive, EIA Directive The measure is explicitly recommended in the EU CIS guidance "River Basins Managament in a changing climate". In the 2007 Communication of water scarcity and droughts the constructions of new water supply dams is cleraly mentioned as subject to EU legislation. It is further stated that interruption of stream flow inevitably change the status of water bodies and as such are subject to specific and strict criteria. In addition, large projects often provoke social and political conflict between donors and receiving basins, which calls their sustainability into question. These specific and strict criteria are outlined in the EU Water Framework Directive. Firstly the WFD explicitly establishes rules requiring the impacts to be monitored (Annex II). Secondly the Directive also requires that the water transfers or diversions do not interfere with the prospects of achieving or maintaining the good ecological status of the river. New transfer can only be commissioned of they do not lead to a deterioration of ecological status or it is proofed that the implied benefits to human health, safety or sustainable development outweigh the benefits of preserving the initial ecological status (Article 4.7). For existing dams and reservoirs it is requrired that the good ecological status or potential is achieved by 2027 latest. This requires to take a set of restuaration measures that ensure that these objectives are met. Such measures are outlined alreday in several river basins managment plans.
Character of measure	Preventing
Sector(s) affected	Water Management, Agriculture, Energy, Forestry
Time to implement	Mid-to long term (25+ yr)
Administration level	National, Regional or River Basin, Municipalities
Examples	Reservoirs were built for multiple purposes: 1. to use the energy potential of rivers 2. for electricity production, 3. to reduce discharge variability for improved navigation or flood control, or 4. to supply water for irrigation and other users [ICOLD, 2007; WCD, 2000]. Basins like the Colorado and Columbia basins and several large basins in India, China and Central Asia rely heavily on reservoir water (e.g. in the Krishna and Huang He, reservoirs more than doubled surface water supply).
Case Studies	Augmenting reservoir capacity is part of the Dutch commitment to an integrated approach to adaptation to flooding. A notable example of demand-driven increases in reservoir capacity occurred in Spain in the late 1990s when over 11 million Spaniards were living with daily water restrictions.

Reference	Biemans, H., I. Haddeland, P. Kabat, F. Ludwig, R. W. A. Hutjes, J. Heinke, and D. Gerten (2011) Impact of reservoirs on river discharge and irrigation water supply during the 20th century, *Water Resources Research*. Ecologic, EEA (2009) Report on good practice measures for climate change adaptation in river basin management plans Graf, W. L. (2006) Downstream hydrologic and geomorphic effects of large dams on American rivers, *Geomorphology*, *79*, 336-360. ICOLD (2007) *World Register of Dams*, International Commission on Large Dams, Paris, France. Ludwig, F., P. Kabat, S. Hagemann, and M. Dorlandt (2009) Impacts of climate variability and change on development and water security in Sub-Saharan Africa, paper presented at Climate Change: Global Risks, Challenges and Decisions, Copenhagen, Denmark, 10-12 March, 2009. Nilsson, C., C. A. Reidy, M. Dynesius, and C. Revenga (2005) Fragmentation and flow regulation of the world's large river systems, *Science*, *308*, 405-408. Poff, N. L., J. D. Olden, D. M. Merritt, and D. M. Pepin (2007) Homogenization of regional river dynamics by dams and global biodiversity implications, *Proceedings of the National Academy of Sciences of the United States of America*, *104*, 5732-5737. Rosenberg, D. M., P. McCully, and C. M. Pringle (2000) Global-scale environmental effects of hydrological alterations: Introduction, *Bioscience*, *50*, 746-751. Syvitski, J. P. M., C. J. Vörösmarty, A. J. Kettner, and P. Green (2005) Impact of humans on the flux of terrestrial sediment to the global coastal ocean, *Science*, *308*, 376-380. Vörösmarty, C. J., M. Meybeck, B. Fekete, K. Sharma, P. Green, and J. P. M. Syvitski (2003) Anthropogenic sediment retention: major global impact from registered river impoundments, *Global and Planetary Change*, *39*, 169-190. WCD (2000) Dams and Development: A new framework for decision-making, The world commission on dams.
Related to REFRESH Measure	M252

REUSE OF TREATED WATER

Measure Number	M13
Description	Recycling of water for non-drinking purposes. Domestic water from baths, showers and sinks (grey water) can be re-used for toilet flushing, laundry/dish washing and garden and irrigation. Waste water can be used for irrigation, glasshouses and industrial processes can be designed to use water in closed circuits.
Measure category	Measure
Measure sub-category	Technical measure related to technical infrastructure
Climate threat	Not enough water (scarcity & droughts)
Link to vulnerability	The measure reduces the sensitivity of pressure on water scarcity by increasing the water use efficiency (i.e. re-use of domestic waste water, adapting industrial processes to use water in closed cycles). The re-use of domestic water for use that allows for less quality reduces the need for high quality drinking water. The water can be used for toilet, garden.

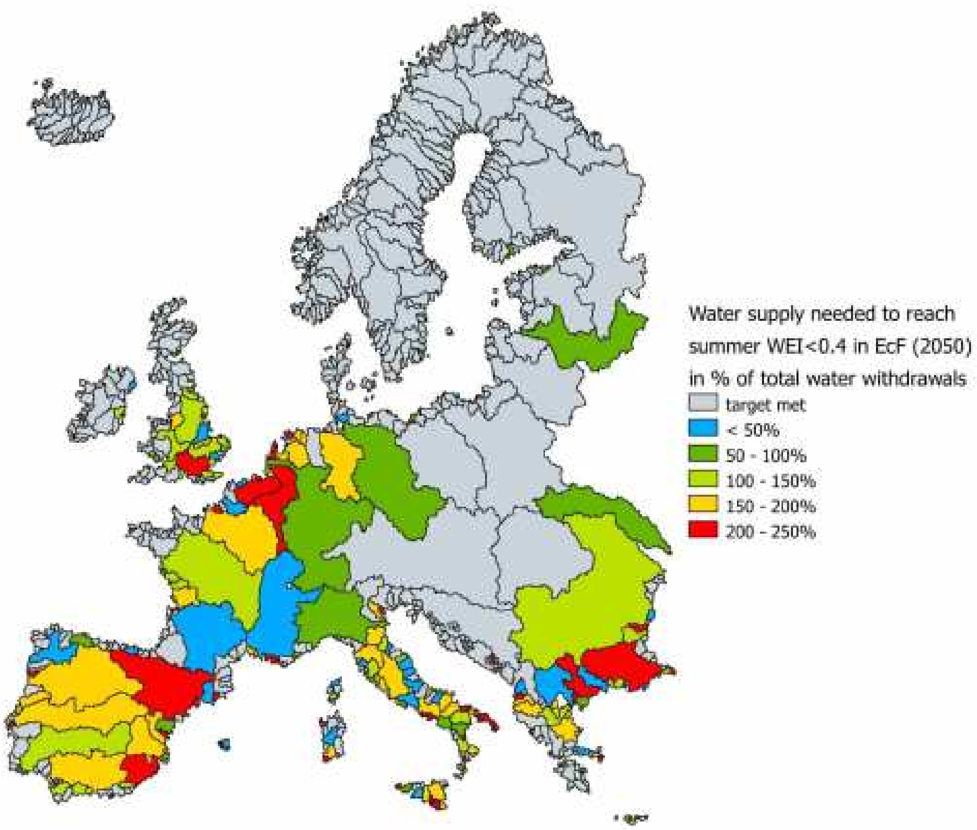
Quantitative results from using the Integrated Assessment Framework (IAF)	
Expert and stakeholder judgement	The measure was assessed to have a number of side effects, such as potential impacts on health, contamination risks, negative effect on water bills and contribution to water conservation. Looking at the efficiency the costs are relatively high, both in economic terms and in carbon emissions; building the Waste-Water Treatment Plant (WWTP) is costly as well as infrastructural development. The benefits are case dependent. The effectiveness of the measure is considered of being dependent on the degree of industrial water use. The feasibility is high, especially on a big scale. However, the measure is difficult to implement in countries without the water quality required by regional law or where socio-cultural acceptance and conflicts may hamper the adaptation. Looking at the institutional setting, the implementation of the measure would require modification in legislation; another concern regards the water quality legislation for waste water irrigation. The urgency & priority is high. Recycling of treated water in agriculture is an important development area in which research and “best practice” is needed to find the most cost-efficient measures.
Qualitative assessment based on literature review	The last decade the water stress (both in terms of water scarcity and quality deterioration) has grown, challenging the availability of water resources. Domestic water from baths, showers and washbasins can be re-used for toilet flushing but requires filtration and disinfection. The benefits include reducing household water demand and ease pressure on the main water supply, reducing upstream energy and environmental costs (Greater London Authority, 2005). Wastewater reuse can therefore be a valuable option for water supply in areas where water is limited. Two types of reuse exist: direct and indirect. Direct reuse is treated wastewater

	that is piped into a water supply system without first being diluted in a natural stream/lake or groundwater. Indirect reuse involves mixing of reclaimed wastewater with another water supply before re-use. Over 200 water reuse projects in Europe have been identified by the AQUAREC project. The potential water reuse is estimated to be in the order of over 3000Mm^3/yr. Spain alone accounts for 1200Mm^3/yr (Report on good practice measures for climate change adaptation in river basin management plans). An example of reuse of treated water is Australia's largest residential water recycling scheme: Rouse Hill. This project started in 2001 and more than 19000 homes are using up to 1.7 billion litres of recycled water each year for flushing toilets, watering gardens, washing cars etc. On average this project has reduced demand for drinking water by about 40%. On the long run, the scheme will serve 36000 homes. The Rouse Hill Water Recycling Plant treats about 4.7 billion litres of wastewater each year for residential use. (http://www.sydneywater.com.au/Water4Life/RecyclingandReuse/RecyclingAndReuseInAction/RouseHill.cfm). The main risks of the reuse of treated water include the uncertainty of the demand of treated waste water since it is not clearly defined and agreed upon. The measure can also result in more social tensions because of non-acceptance. Reuse of wastewater can also be a threat to public health, especially if illegal and unhealthy wastewater reuse practice expands rapidly due to water scarcity, over stringent regulation or the lack of appropriate treated wastewater reuse guidelines and good practice know-how (Mediterranean Wastewater Reuse Report). According to a study by the European Commission on alternative supply option the following principle risks and negative impacts linked to rainwater harvesting have been identified. • Environmental risks – include risks to human health resulting from inappropriate management and maintenance practices of the harvesting systems. The quality of domestically collected rainwater is depending on the management of the roof as well as on the cleaning of the storage facilities. • Economical risks – high investment costs for installing reservoirs and including an additional water distribution system. • Social risks – high investment costs may mean that this technology is not a feasible option for lower income households or tenants. • Global warming risks – this technology does not pose an additional risk to global warming – but its performance relies on the rainfall amount and distribution, which is related to climate change. The identified mitigation measures that deal with the adverse impacts of rainwater harvesting include: • Legal standards – to ensure that there are no dangers of rainwater harvesting water contaminating mains water. • Financial aids or tax breaks – to provide incentives to invest in the technology.
Costs	The possible benefits of the reuse of treated water are various, including economical, social and environmental benefits. Treated wastewater can serve as a more dependable water source, the use can contribute to a more sustainable resource utilisation and sound demand management. The measure can reduce overall water consumption and treatment needs,

	resulting in cost savings. Further, the use of nutrient-rich treated waste water for agriculture may lead to a reduction (or elimination) of fertilizer application or increased productivity and can therefore also contribute to food security. Looking at the environment, the reuse of treated water allows for the conservation and allocation of freshwater and can enhance the restoration of streams, wetlands and ponds (Mediterranean Wastewater Reuse Report).
EU Policies concerned and institutional process	WS&D-policy, Regional Development Fund, EU Energy policy, EU Climate adaptation initiative, marginally affected Urban Wastewater Directive The measure is explicitly recomended in the EU CIS guidance "River Basins Managament in a changing climate" and also addressed in the EU communication "Addressing the challenge of water scarcity and droughts in the European Union". In the 2007 Communication on water scarcity and droughts are also considered as potential solutions across Europe. However it is stated that any definitive Commission position on these options will have to be based on further work on risk and impact assessment, taking into account the specific bio-geographical circumstances of Member States and regions. The measure could be funded under the EU´s Rural Development Program and Cohesion policy.
Character of measure	Preventing
Sector(s) affected	Water management, Agriculture, Energy, Industry, Domestic/ Tourism
Time to implement	Short term (5-25 yr), Mid- to long term (25+ yr)
Administration level	National, Regional or River Basin, Municipality/company
Examples	In general, water can be reused in households, industry, and agriculture. Domestic water requires filtration and disinfection before re-use. Reuse reduces overall water demand, thereby easing pressure on the main water supply and reducing upstream energy and environmental costs.
Case Studies	Australia is a world leader in the use of recycled water. Sydney, is on target to recycle 70 million litres of water a year by 2015, representing approximately 12% of the city's water needs. Water recycling is a key focus of the Metropolitan Water Plan, and they abide by the National Water Commission's recycled water quality standards. Sydney Water runs many water recycling plants as well as operates one of the biggest industrial water recycling schemes in Australia, supplying BlueScope Steel in Port Kembla. They also manage Australia's largest residential water recycling scheme. Over 19,000 homes are using up to 1.7 billion litres of recycled water annually for toilets, gardens, car washing, and other outdoor uses. Brisbane was the first Australian city to use recycled effluent for drinking in 2008.
Reference	Australian Guidelines for Water Recycling: http://www.ephc.gov.au/taxonomy/term/39 Campling, P., et al (2009) Assessment of alternative water supply options – Final summary report, Report to the EU Commission (Service contract No. 070307/2008/496501/SER/D2) Ecologic, EEA (2009)Report on good practice measures for climate change adaptation in river basin management plans Greater London Authority: Adapting to climate change.A checklist for development:

	Guidance on designing developments in a changing climate (2005), www.climatesoutheast.org.uk/.../Adaptation_Checklist_for_Development_Nov_2005.pdf -f Mediterranean Wastewater Reuse Report:http://www.emwis.net/topics/WaterReuse/Final_report.doc Recycled water fact sheet. http://www.nwc.gov.au/resources/documents/RecycledWaterFS-PUB-1007.pdf Recycled water quality standards: a project assessing and communicating risks associated with using recycled water. http://www.nwc.gov.au/www/html/502-recycled-water-quality-standards.asp?intSiteID=1 Recycled water quality standards: a project assessing and communicating risks associated with using recycled water. http://www.nwc.gov.au/www/html/502-recycled-water-quality-standards.asp?intSiteID=1 REFRESH. http://publications.jrc.ec.europa.eu/repository/handle/111111111/15801 Rouse Hill: one of Australia's largest residential recycled water schemes, started in 2001. http://www.sydneywater.com.au/SavingWater/RecyclingandReuse/RecyclingAndReuseInAction/RouseHill.cfm Specific focus related to drinking water in SE http://www.sweden.gov.se/content/1/c6/09/45/95/94d13ec6.pdf Water recycling appliances http://www.aquaco.co.uk/
Related to REFRESH Measure	M084

DESALINISATION

Measure number	M14
Description	Desalination is the process of removing salt from water to make it useable for a range of 'fit for use' purposes including drinking. Advancing technologies could render desalination more energy efficient and reduce operating cost. It could become a viable and weather independent alternative for urban drinking and non-drinking water supplies in the future.
Measure category	measure
Measure subcategory	Technical measure related to technical infrastructure
Climate threat	Not enough water (scarcity & droughts)
Link to vulnerability	Increase water availability (addressing State, reducing Exposure)
Quantitative results from using the Integrated Assessment Framework (IAF)	
Expert and stakeholder judgement	The measure is differently evaluated. At one extreme it reduces the vulnerability to WS&D, but on the other hand it has environmental impact (e.g. producing brine) with high energy consumption and less cost/benefit ratio. The costs depend on the energy price. Another point is the CO_2 emissions due to energy needs for desalination. In principle, this measure expands supply rather than addressing demand. The assessment is relevant for countries

	having a coastal zone, esp. for "brackish" (ground) water, which is already mixed with the intruded seawater. Also the costs for transportation limit the application area. Due to the costs, desalination looks only feasible for the purpose of drinking water not for irrigation issues. If more desalination is applied farmers could suffer high prices for water and the competitiveness of the agricultural sector is affected and will become more vulnerable. Furthermore, the measure moves the problem of freshwater availability to another sector than solving it. Environmental issues arise and desalination simply leads to expansion of these.
Qualitative assessment based on literature review	According to the International Desalination Association, worldwide ~15,000 desalination plants produce more than 58 million m³ of water a day by the end of 2009, with most of the capacity installed in the Arabian Gulf and the Mediterranean (IDA 2011). In Europe 6,061 million m³ water can be desalted per day while more than 75% of the plants use the reverse osmosis technique. In 50 per cent of cases sea water and in 27 per cent brakish water is desalinated. Also waste, pure and river water is used for desalination (NWC 2008a). The Jebel Ali Desalination Plant in the United Arab Emirates is the largest in the world, producing 500 million m³ of water per year (DEWA 2011). Desalination of seawater is also an important source of drinking water in Australian coastal cities, US coastal cities (such as Tampa Bay, Florida), and more arid parts of Europe, including Italy, Spain, Cyprus, and Malta. Whereby Spain by far has the largest desalination capacities in Europe with 2.3 Million m³/d. A doubling until 2015 is expected. For the northern European countries as well as for Greece and Italy the desalination capacity represents less than 1% of the national water use. (Fritzmann et al. 2007) In the Maltese islands, acute water shortage is met by, amongst other things, desalination plants providing more than half of the total water demand (NSO 2011). Furthermore areas with less traditional water shortage, such as metropolitan London, are now building desalination plants for use in shortage emergencies (EEA 2009). The most common methods are multistage flash evaporation (MSF), multi effect distillation (MED), vapor compression (VC) incl. mechanical (MVC) and thermal (TVC) as well as reverse osmosis (RO) (DME 2011). Since 2000, 70% of the installed plants use the reverse osmosis technique for desalination while the current benchmark of energy requirement is about 3.5 kWh/m³. Desalination plants have an impact on terrestrial, marine and atmospheric conditions of the local environment (NWC 2008b); also only 15 to 50 % of the water input produces freshwater while a waste brine solution containing dissolved solids accrues (CCC 2004). Although the energy intensity gets lower the energy use leads to the emission of greenhouse gases (Worldbank 2004). Further on alternative desalination processes like forward osmosis or new membrane materials for the reverse osmosis technique or new technologies like nano-composite particle membrans and carbon nanotube mebrans are in the process of development (NWC 2008a). The importance of desalination is growing inside and outside of Europe. But a high energy use is needed for the desalination process, so that the efficiency has to improved or renewable energy resources has to be integrated. Also the deposition of the brine disposal is still a concern (Campling et al. 2008). These environmental and energy issues leads to the fact, that a decision on the suitability of future desalination plants need to be made on a case-by-case basis accounting for all environmental and economic issues (EEA 2009). Furthermore, seawater desalination should not be used to free up water resources for more irrigation (Worldbank 2004). Within the 6th framework programme of the European Union two projects were funded to

improve desalination methods and use solar and wind power as energy input. These are the MEDESOL (EU Seawater desalination by innovative solar-powered membrane-distillation system) and MEDINA (Membrane-Based Desalination: An Integrated Approach) projects.

Costs

In general the costs have decreased significantly but are depending on plant size, raw water quality, energy costs and terms of financing. In many cases, these costs are similar to incremental conventional bulk water supplies which often involve inter-basin transfers (Worldbank 2004).

In terms of total unit costs of water ($/m^3) two examples in Australia lead to a total cost of 1.16$ to 2.29$ for desalination plants. The product costs depending on the type of technology used is shown in the table below (NWC 2008a).

Operating and maintenance costs of different desalination methods

Technology	Product Costs [US$/m^3]
Multi-Stage Flash (MSF)	$1.10 - $1.50
Multi Effect Distillation (MED)	$0.75 - $0.85
Vapour Compression (VC)	$0.87 - $0.95
Reverse Osmosis (RO)	$0.45 - $0.92

An emission trading scheme with carbon priced at 50$ per tonne CO_2 would add ~16% to operation and maintenance costs. Also desalination is very sensitive to movements in price of electricity. As example if the power cost increase from 0.05$/kWh to 0.2$/kWh the production costs increase by 170% (0.34$/m to 0.91$/m). These assumptions are valid for reverse osmosis with a medium efficiency (4.0 kWh/m) and the production of freshwater with less than 150 mg/L salt and 0.1 mg/L of boron (NWC 2008a).

EU Policies concerned and institutional process

WS&D Policy; Rural Development Regulation; communication on ressource effiency.

The measure is mentioned in the EU communication "Addressing the challenge of water scarcity and droughts in the European Union" even if a definitive Commission position on these option will have to be based on further work on risk and impact assessment, taking into account the specific bio-geographical circumstances of Member States and regions. Some desalination plants haven alreay been fundes under the EU Regional Development Fund (e.g. Allcante II-ES).

The communication on ressource effiency (COM(2011) 21), clearly aims to create a framework for policies to support the shift towards a resource-efficient and low-carbon economy. Desalination is mentiond as an option that provides a solution to water supply problems but it may increase fossil fuel consumption and greenhouse gas emissions.

Character of measure	Preventing
Sector(s) affected	Water management; Domestic/Tourism, Energy, Agriculture
Time	Short term (5-25 yr)
Admin level	National, regional, or municipality/company

Reference

Californian Coastal Commission (CCC)(2004) Seawater Desalination and the California Coastal Act http://www.coastal.ca.gov/energy/14a-3-2004-desalination.pdf

Campling P., de Nocker L., Schiettecatte W., Iacovides A., Dworak T., Kampa E., Alvarez Arenas M., Cuevas Pozo C., Le Mat O., Mattheiß V. and F. Kervarec (2008) Assessment of alternative water supply options.

Deutsche MeerwasserEntsalzung e.V. (2011) Prozesses used for desalination http://www.dme-ev.de/binary.ashx?id=1215&view=download

Dubai Electricity & Water Authority (DEWA))(2011) Power & Desalination Plants Installed Capacity for the year 2010. http://www.dewa.gov.ae/aboutus/electStats2010.aspx

National Statistic Office – Malta (NSO) (2011) http://www.nso.gov.mt/statdoc/document_file.aspx?id=1802

EEA (2009) Water resources across Europe - confronting water scarcity and drought. Report No 2/2009 http://www.eea.europa.eu/publications/water-resources-across-europe/at_download/file

Fritzmann C., Löwenberg J., Wintgens T. and T. Melin (2007) State-of-the-art of reverse osmosis desalination. Desalination, 216, 1-76

International Desalination Association (IDA) 2010: IDA Desalination Yearbook 2010-2011 http://www.desalyearbook.com/

MEDESOL Seawater desalination by innovative solar-powered membrane-distillation system, http://www.eugris.info/DisplayProject.asp?P=4634

MEDINA Membrane-based Desalination: an Integrated Approach http://cordis.europa.eu/fetch?CALLER=FP6_PROJ&ACTION=D&DOC=1&CAT=PROJ&QUERY=013150e433bd:c258:2385f74b&RCN=81392

National Water Commission (2008a) Emerging trends in desalination: A review http://www.nwc.gov.au/resources/documents/Waterlines_-_Trends_in_Desalination_-_REPLACE_%282%29.pdf

National Water Commission (2008b) Executive summaries and conclusions http://www.nwc.gov.au/resources/documents/Trends_in_Desalination_execsummary_oct08.pdf

Worldbank (2004) Desalination: Seawater and brackish water desalination in the Middle East, North Africa and Central Asia : A review of key issues and experience in six countries. Vol. 1-7. http://water.worldbank.org/water/publications/seawater-and-brackish-water-desalination-middle-east-north-africa-and-central-asia-revi

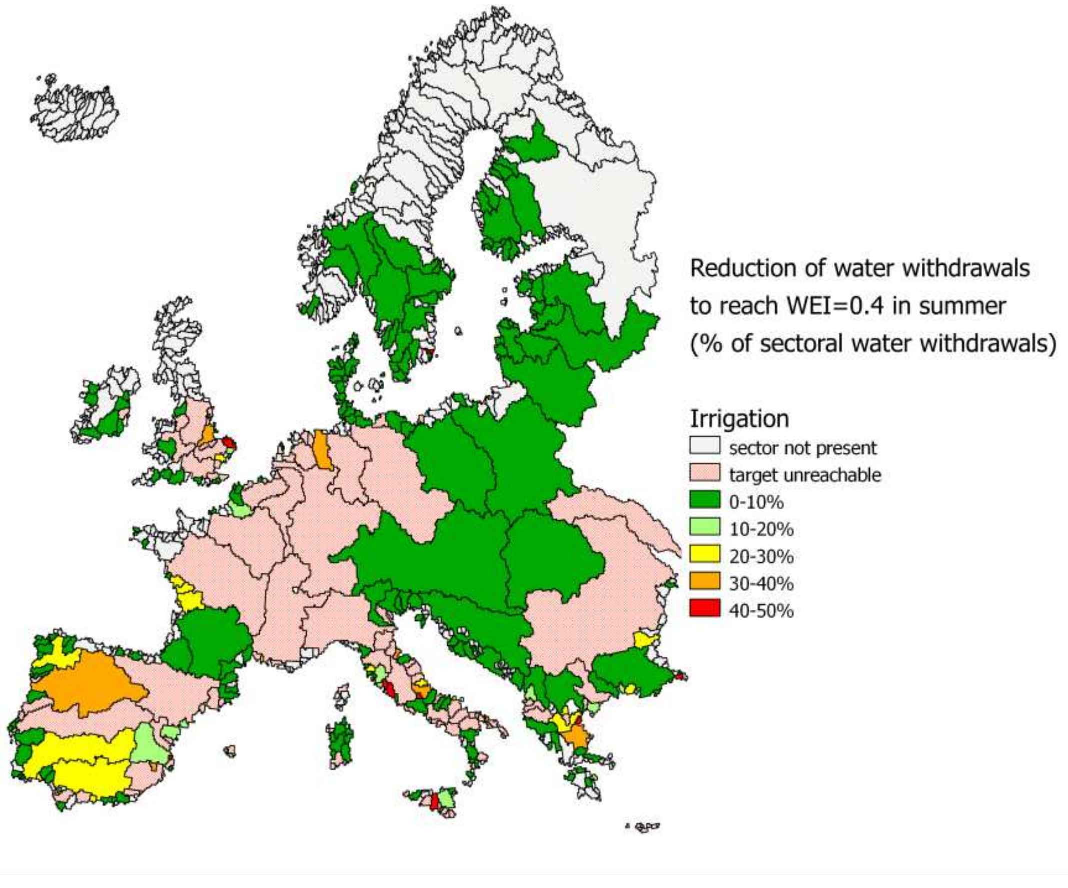
INTER-BASIN WATER TRANSFERS

Measure Number	M15
Description	Shift of potentially large water volumes from a water abundant basin to areas outside of the donor basin where water resources endowment is low or very variable through year, limiting so economic growth.
Measure category	Measure
Measure sub-category	Technical measure related to technical infrastructure
Climate threat	Not enough water (scarcity & droughts).
Link to vulnerability	Addresses water scarcity impact indicator via exposure indicator water availability.
Expert and stakeholder judgement	The stakeholders agreed that the inter-basin water transfers represent a tangible and high valuable measure. However they rose some perplexities about the high economic, social and environmental costs and the technical difficulties in the implementation of the measure. Subjected to a fast track assessment, the stakeholders assigned a medium priority and urgency for the measure. Moreover they assigned a high importance at the EU level, especially because of the possible international problems that the adoption of this measure could rise.
Qualitative assessment based on literature review	There are many attempts to redistribute the water across geographic space, from where it is abundant to places in which economic and social development is obstructed by low natural availability of water or it distribution in time. As the technological and engineering options of water transfer became more sophisticated, large volumes of water had been conveyed from one basin to another; this practice called interbasin water transfer or transbasin diversion. Despite potentially large economic benefit in the receiving basin, the interbasin water transfer practice is controversial on environmental and social grounds. Interbasin water transfer have contributed, along other factors shaping unsustainable water management practice, to the deteriorioration of Aral Sea (Kazakhstan, Uzbekistan) and Glory River (Iraq) (WWF 2007). The examples of water transfer schemes include Tagus-Segura transfer (Spain), Snowy River Scheme (Australia), Lesotho Highlands Water Project (Lesotho-South Africa), Upper Acheloos Diversion (Greece), Rio Saõ Francisco Project (Brazil), Olmos Transfer Project (Peru), South-North Water Transfer Project (China) and others (WWF, 2007). The underlying assumption is that in a river basin with considerable runoff throughout the year water can be abstracted and diverted into another region, rather than letting it flow unexploited into the sea. Water transfers are usually designed to combat water scarcity, i.e. to mitigate a permanent deficit in a region between a limited natural water supply and a high demand that exceeds this supply, rather than to respond to emergencies created by drought. Often, large-scale water transfers have aimed at increasing agricultural productivity through irrigation. Social costs and benefits of water transfers are unequally born by donor and recipient basins. Most environmental and economic benefits are with the recipient basins and may

	include increased safety of public water supply; benefits for (hydro)power generation; flood control; environmental flow regulation; environmental restoration. Furthermore, sharing water in times when it is deficient for natural causes is an act of solidarity between neighbours. Providing water necessary for stopping the critical riverine ecosystems from desiccation prevent biodiversity loss (UNESCO 1999). However, the recipient basin also face environmental risks driven by different physical and chemical properties of received water, forced migration of species and potential threat of biological invasion. In long-term, augmented water availability can stimulate economic activity and higher water consumption and even higher pressure on additional water resources. The boosted water supply may lead to increased agricultural activity on marginal lands or fields previously set aside for environmental purposes. More water-intensive industries might also settle in regions with increased water supply, thus consuming large quantities of the additional water resources made available (EC 2007). In donor basins, the natural flow regime in the donor basin may become seriously disturbed or at least strongly modified. The ecological status of donor rivers may be deteriorated through the modification of the seasonal pattern of natural flow and short-term flow dynamics, affecting erosion, sedimentation, concentration of pollutants and ecosystem services in downstream wetlands, flood plains and estuaries. Negative economic and social effects can occur under conditions of drought and temporarily reduced water resources endowment. Most importantly, the full social costs of water transfers need to be estimated taking into account the financial (implementation and maintenance) costs, resource costs (i.e. costs of foregone opportunities due to the depletion of the resource beyond its natural rate of recharge or recovery) and wide social and environmental costs. Experiences show that the assessment of water transfer projects do not address all the above component, or not in sufficient depth (Albiac et al., 2004). Usually, the transfer schemes are (or should be) approved at the parliamentary level and that the plan should clearly state who bears the implementation costs (UNESCO 1999). The scheme should include limitations or remedy actions aimed to reduce the possible negative consequences of water diversion.
EU Policies concerned and institutional process	Water Framework Directive, Structural Funds, Communication on water scarcity and droughts. In 2007 the European Commission addressed this challenge in a Communication on water scarcity and droughts in the European Union (COM (2007) 414 final). The Communication identified 7 main policy options to address water scarcity and drought issues. There the option of considering additional water supply infrastructures (including water transfers) is ranked as forth option. The Communication makes clear that such transfers are subject to EU legislation (see below). It is further stated that interruption or transfers of stream flow inevitably change the status of water bodies and as such are subject to specific and strict criteria. In addition, large projects often provoke social and political conflict between donors and receiving basins, which calls their sustainability into question. These specific and strict criteria are outlined in the EU Water Framework Directive. Firstly the WFD explicitly establishes rules requiring the impacts to be monitored (Annex II). Secondly the Directive also requires that the water transfers or diversions do not interfere with the prospects of achieving or maintaining the good ecological status of the river. New transfer can only be commissioned of they do not lead to a deterioration of ecological status or it is proofed that the implied benefits to human health, safety or sustainable development outweigh the benefits of preserving the initial ecological status (Article 4.7).

Character of measure	Preventing
Sector(s) affected	Industrial, agricultural, water management.
Time to implement	Mid- to long term (25+ yr).
Administration level	National
Reference	Abrams, R. H. (1983) Interbasin Transfer in a Riparian Jurisdiction. William and Mary Law Review Volume 24(Issue 4, Article 4): European Parliament (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, European Union. Hadjibiros, K. The River Acheloos Diversion Scheme, National Technical University of Athens. Mendiluce, J. M. M. (2003) Water transfers in Spain as a possible means of conflict resolution. Consensus to resolve irrigation and water use conflicts in the Euromediterranean Region. Montpellier, France. Pena de Andrade, J. G., P. S. Franco Barbosa, et al. (2011) Interbasin Water Transfers: The Brazilian Experience and International Case Comparisons. Water Resources Management 25(8) UNESCO (1999) Inter Basin Water Transfer. International Workshop on Interbasin Water Transfer. Paris, France, UNESCO International Hydrological Programme. Potsdam Institute for Climate Impact Research (2009) Cross comparison of climate change adaptation strategies across regions (NeWater) http://www.newater.info/index.php?pid=1049. WWF (2007) Pipedreams? Interbasin water transfers and water shortages, World Wildlife Fund - Global Freshwater Programme
Related to REFRESH-Measure	M211.

IMPROVING IRRIGATION EFFICIENCY

Measure number	M16
Description	A shift from the gravity irrigation to modern pressurised systems (e.g. drip and sprinkler irrigation) and improved conveyance efficiency provide an opportunity for reduced water demand in irrigation.
Measure category	measure
Measure sub category	Technical measure related to technical infrastructure
Climate threat	Not enough water (scarcity & droughts)
Link to vulnerability	The measure reduces water stress (impact) by descreasing the sensitivity (state) of water use. Furtehremore, the measure directly influence management practices (pressure) and resource use efficiency (root causes).
Quantitative results from using the Integrated Assessment Framework (IAF)	
Expert and stakeholder judgement	The measure shows evident benefits in all areas with high agricultural share of freshwater use. Its implementation is deemed pertinent and urgent. Compared to other measures, the improved irrigation efficiency showed high expectations and interest, particularly by experts

	and stakeholders from North and South-East Europe with high irrigation potential. It is a typical no-regret measure, but hardly combinable with other measures. The positive benefits can only be realized if the conserved water is not immediately relocated and used for new crops and extended irrigation. Consideration should be paid to the reduced return flow and thus reduced water availability downstream.
Qualitative assessment based on literature review	Soil moisture and conditions are affected first during a prolonged period of deficient precipitation. Soil moisture, also referred to as 'green water', is the component of the hydro-meteorological cycle that is accessible by the roots of plants, enabling them to grow (Falkenmark & Rockstrom 2006). Irrigation is the most widely used way to combat the soil water deficiency and, accordingly, by far the prevalent water use in agriculture. In Europe, agriculture accounts for approximately 23.6 per cent of total water abstraction. The role and the impact of irrigation varies across the regions and prevailing climatic conditions: while in southern Europe irrigation is an essential ingredient of agricultural production, in Central and Northern Europe fields are irrigated sporadically and mostly in dry summer periods. In Italy or Spain the water consumption for agriculture can be as high as 80% (Eurostat 2008). The expected climate change impacts on agriculture, however, will most likely reverse these initial water savings. According to the latest IPCC report (Parry *et al.* 2007), the irrigation water demand may increase substantially for the Mediterranean region (+2-4% for maize and +6-10% for potato by 2050) and some parts of Central and Eastern Europe. Irrigation will become necessary in some other parts of Europe, such as Ireland, while the demand will decrease in parts of northern Europe where precipitation is likely to increase. The energy sector will put additional strain on water resources. Biomass production for energy purposes is expected to increase from 2 Mtoe in 2003 to 102-142 Mtoe in 203 (EC 2005). This will moderately increase the water demand. The bulk of studies address irrigation efficiency (Katerji & Bethenod 1997; Nwadukwe & Chude 1998; Burke *et al.* 1999; Malano & Wei 2003; Tennakoon & Milroy 2003; Taylor 2008; Hassanli *et al.* 2009) and water-conserving soil management practices. The term 'efficiency' is used differently and sometimes, wrongly implies that the water that is not consumed in the transpiration is 'lost' (Jensen 2007). In truth, the part of the water applied to the field but not consumed through evapotranspiration – the return flow – remains available for use downstream. A shift from the gravity irrigation to modern pressurised systems (e.g. drip and sprinkler irrigation) and improved conveyance efficiency[2] provide an opportunity for reduced water demand in irrigation, but at a high price[3]. Given that the water price and the fixed costs of water provision for agriculture are heavily subsidised (OECD 2008), there are few incentives for farmers in many EU countries to implement more efficient technologies. Water pricing and recovery of the costs of irrigation investment, operation, and maintenance have been contentious issues for many decades (Easter & Liu 2005). A small, but growing amount of attention has been paid to deficit irrigation (Fereres & Soriano 2007; Lorite *et al.* 2007; Payero *et al.* 2009; Rodrigues & Pereira 2009); or more specifically, irrigation below full crop-water requirements (evapotranspiration) aiming at the maximum production per unit of water consumed (Fereres & Soriano 2007).

[2] Conveyance efficiency refers to the water losses from the point of abstraction to the distribution network (Lallana *et al.* 2001)

[3] According to Lallana et al. (2001) the costs of pressure irrigation is of the order of 10.000 Eur per hectare, a price which often exceeds the productive capacity of the respective fields.

EU Policies concerned and institutional process	The EU policies throughout which the measure could be promoted include Water Framework Directive (WFD, water pricing), EU Drought Policy, Rural Development, Direct Payments, and Communication on Resource Efficiency. WFD: Increasing the price of water for irrigation will provide an incentive for more efficient water use in agriculture. Even more so if the price scheme will include scarcity component linked to the actual or expected water availability. Attention should be paid to the combined effect of energy and water prices on farm level. The agricultural demand for water declined between 1997 and 2005 by about 20% on average in Eastern Europe and some 56% in Western Europe, a trend attributed to a decrease in irrigable areas in some countries and more efficient water use in others (EEA 2009). The recent reforms of the Common Agricultural Policy (EC 2003) helped to curb water demand for irrigation. Particularly, the 'decoupling' subsidies for specific crops and encouraging the modernization and the sustainability of the farming practices had positive effects on water consumption. An additional reduction in water demand may occur through the reform of the Common Market Organisation of fruit and vegetables and the wine sector. The unintended side effects of the measure (extension of irrigated land) can be controlled by defining requirements which, only if met, would allow to access the funding schemes for new irrigation technology. These requirements may include minimum net water saving at the river basin scale or limiting the extension of irrigated land.
Character of measure	Preventing
Sector(s) affected	Agriculture, energy (though higher energy demand),Water management, other sectors indirectly
Time	Short term (5-25 yr)
Admin level	River basin
Case studies	Improving irrigation efficiency is an important component of climate change adaptation in the arid valleys and plateaus of the South Tyrol and Valais parts of the Alps. The South Tyrol area has traditionally adapted by using more efficient irrigation methods, such as introducing drip irrigation for fruit growing. In Cyprus, over 95% of the total irrigation land is served by modern irrigation methods with conveyancs efficiency averaging 90-95%. In the Guadalquivir river basin in Spain, the old open channel networks are being replaced by 'on-demand' pressurised networks to acheive more efficient conveyance. Micro irrigation now represents 45% of all irrigated lands there.
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Related to REFRESH Measure	M010/M186

WATER SENSITIVE FOREST MANAGEMENT

Measure Number	M17
Description	Forest management measures can increase water yield, regulate water flow, and reduce drought stress for a forest e.g. during current and future low-flow conditions. Measures that address existing forests include (1) reduced density of stand stocking; (2) shorter length of the cutting cycles; (3) planting hardwood species; (4) regeneration from seedlings rather than sprouts (5). Afforestation, in particular near watercourses, brings benefits for the regulation of water flow and the maintenance of water quality, reducing the intensity of floods and the severity of droughts. The digital classification of forest sites can be used for analysis, consultation, and developing adaptation recommendations.
Measure category	Measure
Measure sub-category	Technical measure related to green infrastructure
Climate threat	Not enough water (scarcity & droughts); Too much water (flooding, sea level rise, coastal erosion); Deteriorating water quality & biodiversity.
Link to vulnerability	Addresses water stress Impact indicator via State indicator water use.
Expert and stakeholder judgement	Among the strategies aimed to achieve a water sensitive forest management, stakeholders highlighted the limitations posed by the digital classification of the forest sites. Subjected to a fast track assessment, the stakeholders assigned a middle priority and urgency for the measure. It has been recognised some value to the modification of the silvicultural thinning and rotation period, but with some perplexities about the implementation. The stakeholders pointed out the potential limitations and costs of the strategy aimed to adapt management rules in silviculture to improve tree water balance. In general the measure has not been considered a priority because of the possible side effects and the scarce efficiency and effectiveness. Afforestation has been considered highly valuable, pointed to the high benefit even in case of less pronounced climate change impacts.
Qualitative assessment based on literature review	Forests have been associated with improved water yields. As a general rule, however, in temperate climate conditions, forests consume more water than other land uses, increasing pressure on water resource security. In fact, an increasing number of studies have challenged the popular idea that more forests imply more and better water (Jackson et al 2005, Calder 2007, van Dijk 2007). To identify and correctly apply forest management to reduce water use is therefore a crucial aspect regarding water scarcity. Different are the effects of the forest management on the soil water storage. Literature presents an equation to describe the water flow of a natural ecosystem: the water balance equation. The change in soil water storage for a given period is related to the amount of precipitations, rate of evapotranspiration (combination of the evaporation of the plants and the transpiration of the land surface to the atmosphere), surface runoff and deep drainage in a given period of time. The studies conducted by Joffre and Rambal (1993) showed the effects of increasing the number of trees in the system under consideration, keeping the remaining variables constant. It is possible to verify an increase in the level of evapotranspiration, with a

	consequent raising pressure on water resources. From the other side, it is possible to register a consistent decrease of the level of surface runoff and deep drainage. These studies showed that the soil water storage is positively influenced by the increase of the number of trees. Focusing on afforestation, van Dijk 2007 presents a review of the literature. The author concludes that the main issues determining the impact of afforestation on water are: (i) forest hydrology and related soil properties, (ii) benchmark landscape condition and (iii) water resources system configuration. If correctly designed though, afforestation policies can alleviate negative effects and/or create additional benefits. One way to do this consists in establishing new plantations on upper slopes. Doing so reduces negative impacts on streamflow (Vertessy et al 2003). Trees located in border of plantations have greater access to adjacent water; as a result the perimeter-to-area ratio may also be defined as to reduce forest water consumption (Silberstein et al 2002). Finally, forest plantations are less nutrient and pesticide intensive than other land uses and may therefore consist in an instrument to grant higher quality water (Hamilton 2008). If not well managed, however, or if established in places with high pollutant concentrations, afforestation may actually result in higher water acidification (IUFRO2007). Various forest management practices may also be used to reduce forest negative impacts on water resources. Particularly relevant in this context are practices such as harvesting, thinning and species mix choice. Canopy structure of mixed species plantations reduce transpiration, imposing less pressure on water if compared to mono-species plantations (Forrester 2007). By decreasing the number of trees in the stand, thinning may also be used to mitigate excessive forest water use. The positive impact of this measure may however be offset by increase water consumption due to increased growth of the remaining trees (Swank et al 1988). Depending on the fraction of harvested land and on harvesting patterns, water yield usually increase after timber harvest. Different harvesting regimes may therefore impact differently on water resource security. Having this is mind, Hubbart et al 2007 have investigated the impact of different harvesting regimes on Water Yield in the continental/maritime climate region of western United States. Finally, shorter rotations decrease the period of time for which canopy is completely closed and may therefore also reduce water forest consumption. A relatively constant population of the stand by young trees may, however, counterbalance this effect. In addition, the use of fast growing species is usually more water intensive than slow growing species with higher rotations. While the use of forests has been increasingly advocated for a wide range of different objectives, knowledge of the impacts of such programs on water scarcity still poses major research questions to the scientific community (Vanclay 2009).
EU Policies concerned and institutional process	Water Framework Directive, Habitat Directive, EU Biodiversity Action Plan, Habitat Directive, Rural Development Regulation CAP formulates common rules and priorities to be pursued across sectors and rural areas. As forestry is the predominant land-use besides agriculture in rural areas across Europe, the CAP also addresses forests and forestry issues. Many measures supported by the Rural Development Programme of CAP (axis 2) are directly linked to forestry protection and rehabilitation measures, including forest environment payments introduced for voluntary commitments to maintenance of water resources and water quality. WFD: Via the WFD also forestry services are affected. To support Member States in developing their Programme of Measures (PoMs), the European Commission financed a project compiling a catalogue of measures to tackle agriculture pollution, which also includes forestry related measures such as afforestation of agricultural land. Measures within the PoMs are directly linked with measures under axis 2 of the Rural Development

	Programme (RDPs) (described above). And other EU policies that are related to forest issues such as EU Forestry Action Plan (FAP), Natura 2000 and the Biomass Action Plan (BAP).
Character of measure	Preventing
Sector(s) affected	Forestry, Water management, Agriculture
Time to implement	Short term (5-25 yr); Mid- to long term (25+ yr)
Administration level	Municipality/company, Regional or RB, National Forest enterprises within river basin district, modify forest management measures - regional and national level
Examples	(1) reducing stand stocking to below 70% relative density; (2) using short cutting cycles; (3) using short rotations; (4) encouraging hardwood species; (5) encouraging regeneration from seedlings rather than sprouts; and avoiding conversion to softwood species from hardwood species.
Case studies	The Silvistrat project of the European Forest Institute has been developing adaptive management strategies for sustainable forest management in European forests under global climate change.
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Related to REFRESH-Measure	M392

RIVER RESTORATION

Measure number	M18
Description	The measure focuses on the increase of flow capacity of the river system during flood events, and/or to reduce the speed of water flow. This also helps to increase habitat quality and groundwater recharge.
Measure category	Measure
Measure sub-category	Technical measure related to green environment
Climate threat	Too much water (flooding, sea level rise, coastal erosion), Not enough water (scarcity & droughts)
Link to vulnerability	The measure reduces flood risks (people and area flooded) by decreasing the exposure pressure on excess water (by increasing storage capacity in the river) through changing morphology.
Expert and stakeholder judgement	The measure has been assessed to have a relatively high urgency and priority since the measure is directly related to the WFD goals. Implementation of the measure could have an effect on navigation, tourism, agriculture, drainage and it has ecological value. However, it is not always feasible to implement because sometimes the river margins don't allow to restore the river. In order to implement this measure there is a need of money and cooperation among all public administrations, requirements are thus high. Since the measure is very much case specific it is impossible to say something about the efficiency or the effectiveness of the measure.
Qualitative assessment based on literature review	River restoration embraces a great variety of measures that have in common that they restore natural functions of rivers, that were lost or degraded by human intervention. Many European rivers have often been modified in the past decades to serve only one dominant function. However, one-sided use, disregarding of different functions, is no longer optimal. An integrated approach is prerequisite for success. Achieving river restoration implies that apart from the technical and ecological considerations, raising support and creating public awareness are just as essential to obtain results (source: River restoration in Europe, practical approaches). There has been increasing interest in Europe in rehabilitation of watercourses and river valley ecosystems. An example is the spatial planning project "Room for the River" in The Netherlands, which include a number of measures leading to improvement of stream morphology and floodplain restoration. It was initiated in 2006 and will be on-going until 2015. The development of floodplains and wetlands helps to retain and slowly release (flood)water, facilitate groundwater recharge, provide seasonal aquatic habitats, support corridors of native riparian forests and create shaded riverine and terrestrial habitats. Tidal wetlands as buffers help maintain fuctioning estuarine ecosystems and create natural land

	features that act as storm buffers, protecting people and property from flood damages related to sea-level and storm surges. Reversal of delta island subsidence sediment and soil accretion is a cost effective natural process that can help sustain the delta ecosystem and protect delta communities from inundation. The success of restoration projects was subject of a study[4] that evaluated by comparing 26 pairs of non-restored and restored river sections in Austria, Czech Republic, Germany, Italy and the Netherlands. The outcomes of this study are: Restoration had significantly improved the diversity of mesohabitats in 83 per cent of the studied river sections. For microhabitats, restoration had a significant positive effect on diversity at 69 per cent of sites but a significant negative effect at 15 per cent of sites. More specifically, the impacts of restoration on river site characteristics such as shore length, habitat width and the actual number of mesohabitats and microhabitats were greater in Southern Europe and mountainous regions. Active restoration projects, such as removing banks and placing logs in the river channel, had a greater effect on the characteristics of mesohabitats and microhabitats, particularly for Southern European sites and Central European mountain rivers. The impact of passive restoration projects, such as abandoning river maintenance and removing livestock, was smaller and mainly restricted to mountain rivers in Central Europe. The effect of restoration on the biodiversity of benthic invertebrates was small or not detectable. This supports the results of previous studies which have found that enhanced habitat diversity has little or no effects on benthic invertebrate biodiversity. The results indicated that, while restoration can have an impact at the level of habitats, it does not produce significant changes in biodiversity of benthic invertebrates when applied to relatively short river sections, several hundred metres in length. Passive river restoration, which is less expensive and easier to apply to longer stretches of river, may lead to the same impact on the catchment area as expensive active restoration techniques. Efforts at the larger catchment scale which tackle wider problems, such as water quality, could have greater effects on the invertebrate community.
EU Policies concerned and institutional process	Water Framework Directive, Floods Directive, Natura2000, WS&D policy, Rural development Policy, Interreg, EU Biodiversity Action Plan. River restoration is clearly a measure required under the WFD as several European Rivers show a high level of morphological destruction (see various reports of the CIS working Group on Hydro-morphology) resulting in less than good status. The WFD sets a framework to improve this situation. The measure is already mentioned in several RBMPS published. It can be funded under the Rural development Policy of the CAP as well as under Interreg. Any river restoration project also contributes to the EU policy objective related to biodiversity and nature protection.
Character of measure	Preventing

[4] http://ec.europa.eu/environment/integration/research/newsalert/pdf/201na1.pdf

Sector(s) affected	Water management, Agriculture, Industry, Navigation, Domestic/ Tourism
Time to implement	Short term (5-25 years)
Administration level	National, regional or River Basin, Municipality
Examples	The development of floodplains and wetlands helps to: retain and slowly release (flood)water, facilitate groundwater recharge, provide seasonal aquatic habitats, support corridors of native riparian forests and create shaded riverine and terrestrial habitats. Tidal wetlands as buffers help maintain functioning estuarine ecosystems and create natural land features that act as storm buffers, protecting people and property from flood damages related to sea-level and storm surges. Reversal of delta island subsidence by sediment and soil accretion is a cost effective natural process that can help sustain the delta ecosystem and protect delta communities from inundation.
Case Studies	**Case studies:** Various river restoration projects to mitigate the impacts of hydromorphological modifications are part of the Anglican River Basin Management Plan in the United Kingdom. The level of the projects varies from catchment to landscape level. Ecosystem restoration in general is also a component of California's Climate Adaptation Strategy. Floodplain restoration is being driven by the WFD, with early projects taking place in the Rheinvorland-Süd on the Upper Rhine, the Bourret on the Garonne, and the Long Eau River project in England. Germany's largest restoration area, Anklamer Stadtbruch, consists of ca. 2000 ha of fen and bog woodlands, former fen grasslands, and the Peene River. The EU-funded REFRESH project is tasked with developing adaptation strategies to mitigate the impacts of climate change on European freshwater ecosystems, including relevant restoration measures. http://ec.europa.eu/environment/integration/research/newsalert/pdf/201na1.pdf
Reference	River Basin Management Plan Anglian River Basin District, Annex C: Actions to deliver objectives, 2009. http://wfdconsultation.environment agency.gov.uk/wfdcms/en/anglian/Intro.aspx Bernhardt, E.S., M.A. Palmer, J.D.Allan, G.Alexander, K. Barnas, S. Brooks, J. Carr, S. Clayton, C. Dahm, J. Follstad-Shah, D. Galat, S. Gloss, P. Goodwin, D. Hart, B. Hassett, R. Jenkinson, S.Katz, G.M.Kondolf, P. S. Lake, R. Lave, J. L.Meyer, T.K. O'Donnell, L. Pagano, B. Powell & E. Sudduth (2005) Synthesizing U.S. River Restoration Efforts. Science 308: 636-637. California Natural Resources Agency: The 2009 California Climate Adaptation Strategy Discussion Draft http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-D.PDF REFRESH. http://publications.jrc.ec.europa.eu/repository/handle/111111111/15801 River restoration in Europe, practical approaches http://distance.ktu.lt/kbridge/IRBM/Unit1_2/resources/documents/Annex1_1.2F.pdf Science for Environment Policy, European river restoration projects need to widen their scope, June 2010. http://ec.europa.eu/environment/integration/research/newsalert/pdf/201na1.pdf

Related refresh measure	M053

SUSTAINABLE DRAINAGE SYSTEMS (SUDS)

Measure Number	M19
Description	Drainage systems can be improved by shifting to Sustainable Drainage Systems (SUDS), whose installation mimics natural drainage patterns to attenuate surface water run-off, encourage the recharging of groundwater, provide significant amenity and wildlife enhancements, and protect water quality.
Measure category	Technical Measure
Measure sub-category	Technical measure related to green infrastructure
Climate threat	Too much water (flooding), Deteriorating water quality and biodiversity, Not enough water (scarcity and droughts)
Link to vulnerability	Addresses the impact indicators water stress and damagess and losses from flooding via pressure indicator land use changes.
Expert and stakeholder judgement	Subjected to a fast track assessment, the stakeholders assigned a high urgency and priority for this measure.
Qualitative assessment based on literature review	The drainage of urban areas can be designed to reduce the influence of urbanisation on run-off (attenuating flood peaks, reducing the urban pollution load in run-off), as well as reduce the risk of damages to real estate and waterbodies due to drainage system failure by flooding. Design and infrastructure changes can also have positive effects on water quantity by facilitating groundwater recharge and help meet water efficiency targets by using rainwater for non-potable uses. Sustainable Urban Drainage Systems (SUDS) are made up of one or more structures built to manage surface water runoff; they tend to mimick natural drainage (Greater London Authority, 2005). SUDS often incorporate soil and vegetation in structures that are usually impermeable (e.g. green rooftops); the uptake and passage through soil and vegetation reduces runoff velocity and improves water quality (Nõges et al, 2010). Surface permeability in urban areas can be increased by using permeable paving where appropriate (e.g. footpaths, car-parking areas, access roads), thus reducing surface run-off and increasing groundwater recharge. The harvesting and use of rainwater can reduce the pressure on drinking water resources. Infiltration devices, such as “soakaways”, allow water to be drained directly into the ground; basins, ponds, and urban infrastructure such as children’s playgrounds can be designed to hold (excess) water when it rains (Greater London Authority, 2005). The applicability of SUDS is considered virtually unlimited in most urban areas. The wide array of available techniques allows application in areas with very different soil permeability, in contaminated areas and areas where space is limited (Nõges et al, 2010). The importance of institutional frameworks (governance and management) for successful and widespread implementation of these measures is considered central. The bottlenecks are of institutional and social nature (Ellis and Revitt, 2010). Planning processes require

	earlier and more intense consultation with different planning authorities (White and Howe, 2005). The importance of collaborative stakeholder participation and information systems is highlighted in the literature (e.g. Ellis and Revitt, 2010; White and Howe, 2005; Mailhot and Duchesne, 2010) for the successful implementation of these measures, as well as for the achievement of integrated urban drainage management (IUDM). Choices relating to sustainable urban surface water drainage are seen as rather about the resolution of conflicts between different interests than choice being reducible to technical optimisation (Ellis and Revitt, 2010).
Costs	Studies on costs of SUDS and SUDS retrofitting mainly suggest these measures are attractive in economic terms. Studies performing comparative cost analysis between traditional drainage and SUDS are supportive of SUDS: well designed and maintained SUDS would be more cost effective to construct, and would cost less to maintain, than traditional drainage solutions (e.g. Duffy et al., 2008). A Cost-Benefit Analysis approach is hampered by the comparative lack of studies economically valuating benefits of SUDS, but first studies show that the benefits of SUDS in new developments significantly outweigh costs, e.g. by factors of 2,3 or 1,5 (depending on assumptions) over the next 20 years (Petrova, 2011). A cost-benefit analysis of retrofitting of different SUDS techniques performed by the UK's Environment Agency suggested that 2 of 4 techniques can always be considered to provide net financial benefits, whereas for the remaining 2 local conditions will determine if the benefit-cost ratio is larger or smaller than 1 (Gordon-Walker et al., 2007). (Due to methodological difficulties, the economic valuation of the benefits of SUDS has yet to incorporate hard-to-monetarise benefits such as reduction in diffuse pollution, additional recharge to aquifers, deferred investments in sewage treatment capacity, and amenity value (Gordon-Walker et al., 2007; Petrova, 2011).)
EU Policies concerned and institutional process	Water Framework Directive, Floods Directive, Communication on Water Scarcity and Droughts, Urban Wastewater Treatment Directive, Eurocodes, European Regional Development Fund, Council Reg (EC) N° 1083/2006, the European Social Fund, Cohesion Fund, Rural Development Fund. The possibilities of EU policies promoting these decentralized measures seem limited; implementation of this measure is more strongly related to national and regional regulations regarding building codes, drainage codes, flood prevention, and water quality. EU policies (European Regional Development Fund, the European Social Fund, Cohesion Fund, EU Rural Development policies) could promote these measures in the case of larger infrastructures such as those related to drainage systems, both in the construction of new ones or renovating existing systems. Future policy and regulatory efforts addressing building standards, such as the current Eurocodes, could foster the use of SUDs such as green rooftops in their specifications when appropriate.
Character of measure	Preventing
Sector(s) affected	Water management, Domestic / Tourism
Time to implement	Short term (5-25 yr)
Administration level	All levels involved: National, regional, and municipality.
Reference	Duffy, A.; C. Jefferies, G. Waddell, G. Shanks, D. Blackwood and A. Watkins (2008) A cost comparison of traditional drainage and SUDS in Scotland. Water Science & Technology—

	WST, Vol. 57, Issue 9, 2008. Ellis, J. B.; Revitt, D. M. (2010) The management of urban surface water drainage in England and Wales. Water and Environment Journal 24 (2010) 1–8. Gordon-Walker, S., Harle, T., and Naismith, I. (2007) Cost-benefit of SUDS retrofit in urban areas. Environment Agency Science Report – SC060024, November 2007. Greater London Authority (2005) Adapting to climate change: a checklist for development. Guidance on designing developments in a changing climate. Produced by the Three Regions Climate Change Group, made up of representatives from the East of England Sustainable Development Roundtable, London Climate Change Partnership and the South East Climate Change Partnership. Available at http://www.sfrpc.com/Climate%20Change/11.pdf Mailhot, Alain; Duchesne, Sophie (2010) Design Criteria of Urban Drainage Infrastructures under Climate Change. Journal of Water Resources Planning and Management, March/April 2010. Nõges, T., Nõges, P., Cardoso, Ana Cristina (2010) Review of published climate change adaptation and mitigation measures related with water. JRC Scientific and Technical Reports. Petrova, T. (2011) Cost Benefit Analysis of SUDs. Harrow Way SUDs, Kent. Paper and Presentation. Available at website of WEM the environment magazine http://www.wemmagazine.co.uk/media/366762/WAPUG_SUDS_Presentation%20by%20Tatyana%20Petrova_052011.pdf REFRESH. http://publications.jrc.ec.europa.eu/repository/handle/111111111/15801 White, I., Howe, J.(2005) "Unpacking the Barriers to Sustainable Urban Drainage Use". Journal of Environmental Policy & Planning. Vol. 7, No. 1, March 2005, 25–41
Related to REFRESH-Measure	M005

SHORELINE MANAGEMENT

Measure Number	SA11
Description	Shoreline management has been introduced into coastal management practices since the 70ies of the past century (see for instance Washington State Shoreline Management Act adopted in 1971) giving way to holistic and sustainable practices of beach and shoreline management including control of erosive processes and coastal flooding. Basic principles of shoreline management acquire an increased importance under the prospective of raising sea level rise under changing climatic conditions.
Measure category	Support action
Measure sub-category	Management plans
Climate threat	Too much water (flooding, sea level rise, coastal erosion).
Link to vulnerability	Addresses impact indicator area/people/assets flooded via sensitivity pressure indicator management practices.
Expert and stakeholder judgement	The stakeholders agreed that the shoreline management plans represent tangible and risk-free solution, pointed to the high benefits even in case of less pronounced climate change impacts. Subjected to a fast track assessment, the stakeholders assigned a high priority and urgency for the measure.
Qualitative assessment based on literature review	Shorelines have always adapted to changing environmental conditions and this fact has produced a long history of management interventions in order to protect human settlements and infrastructures from negative impacts of these changes. Under the prospective of ongoing rapid climatic changes and connected rising sea levels on the one side, and the increasing importance of coastal zones both for human activities concentrated to a high and ever increasing percentage in coastal areas and the share coastal areas hold of global biodiversity, protection and management of coastal areas and coastlines is acquiring an even higher importance (O'Connor et al. 2009) Processes creating concern for human activities situated in coastal areas are mainly related to coastal submergence, coastal flooding in case of extreme events and to processes provoking coastal erosion and slope instability and call for holistic and integrated management principles for the protection of coastlines and the assets situated close to them. Shoreline management plans, based on management units which are delimited in correspondence to relevant sediment processes, such as sediment cells or sub-cells as adopted in England and Wales (Cooper and Pontee 2006), on the Dutch coast, the Wadden sea, and in Normandy (Eurosion 2004). Shoreline management cells comprise coastline and associated near-shore areas where movement of sediments is largely self-contained (Eurosion 2004). The choice of sediment cells as management units which are relevant for sediment processes, should avoid problems created by isolated defence measures which frequently create sediment losses in other places (Hutchison et al. 2006). The basic principles for shoreline management based on coastal sediment cells are: 1. Conservation of sediment quantities (in motion or dormant) within the coastal

system

2. Preference for activities based on or working with natural processes or leaving natural processes as undisturbed as possible
3. Use of hard constructions for keeping sediments in its position only in absence of alternatives (Eurosion 2004)

While the concept has allowed for a more holistic vision of human intervention into coastal processes, limitations of the concept of sediment cells is mainly connected to the absence of time horizons, as boundaries of coastal cells cannot be considered stable over long time horizons (Cooper and Pontee 2006; Eurosion 2004).

In relation to climate change and rising sea levels. policy options for shoreline management can be grouped mainly in five principal directions:

(a) do nothing, (no investment in coastal defence structures, i.e. no shoreline management activity)

(b) hold the line (maintaining the existing defence line by maintaining or improving the standard of protection, upgrading existing defences or maintain the standard of protection provided by the existing defence line),

(c) managed realignment (Identification of a new line of defence landward of the original defences .and, where appropriate, constructing of respective new defences);

(d) move seaward (advancing the existing defence line seawards by constructing new defences, used in cases of important land reclamation projects), and

(e) limited intervention (limiting coastline interventions to natural processes for risk reduction while allowing natural coastal change. (slowing down rather than stopping coastal erosion and cliff recessions (e.g. nourishments), to measures that address public safety issues (e.g. flood warning systems, dune and forest maintenance, land use planning defining building restrictions in coastal strip) (Eurosion 2004).

Among these solutions, the “hold the line” represents probably one of the most frequently chosen option, although the application of long term visions (ideally 100 years) and cost-benefit considerations for the choice of management options might suggest solutions as for the application of managed realignment or doing nothing. Principles for the redaction of shoreline management plans ideally are part of more integrated coastal zone management (ICZM) processes, coordinating all forms of coastal uses and land use plans. Like ICZM, shoreline planning and management is a socio-political activity which needs to be based on scientific evidence, and needs to create direct connection to land use planning in the consideration of risks (i.e. flood risk) for natural, cultural and socio-economic resources in coastal zones and the delimitation of the interested areas (Hutchison et al. 2006). The framework for shoreline management created by the British Government requires the application of cost-benefit considerations (DEFRA 2009), and has triggered some cases where managed realignment strategies have been considered. In these cases issues connected to the compensation of losses, the management of slowly increasing economic and social blight interesting local communities involved in managed realignment processes have been risen (Milligan et al. 2006). New forms of financing of coastal defences (Environmental Agency 2009) and for compensation schemes for both losses in property and in economic (agricultural) activities will need to be set up.

According to O’Connor et al. (2009), the existence of a national framework for decision making acts in favour of more sustainable solutions, rather than solutions determined exclusively by local authorities more exposed to pressures from local stakeholders. On the other hand side, systems as those applied in Ireland, where coastal management processes are exclusively managed by local authorities and thus more subject to preferences by locals stakeholders have the advantage of reacting faster to local problems and take more

	advantage of local expertise, but they lead more frequently to economically less sustainable “hold the line options” (O’Connor et al. 2009).
EU Policies concerned and institutional process	EU Marine Strategy Framework Directive: The aim of the European Union's ambitious Marine Strategy Framework is to protect more effectively the marine environment across Europe. The objective is to achieve good environmental status of the EU's marine waters by 2020. The Marine Strategy has a special focus on climate change. Under the Marine Strategy every Member State has to develop a programme of measures with which a good environmental status can be reached or kept. The European Parliament and the Council adopted in 2002 a Recommendation on Integrated Coastal Zone Management (ICZM) (2002/413/EC). The Recommendation includes the principles of sound coastal planning and management. It outlines steps which the Member States should take to develop national strategies for ICZM, based on common ICZM principles. At the moment the ICZM Recommendation is under review. 2008, the European Commission established the OURCOAST initiative which has the objective to ensure that lessons learned from the coastal management experiences and practices will be shared and made accessible to those who are seeking sustainable solutions to their coastal management practices. OURCOAST has a focus on adaptation to risks and the impacts of climate change. EU Flood Directive addresses also coastal floods and measures have to be included in the flood risk management plans.
Character of measure	Preparatory, Preventing,
Sector(s) affected	Water Management, Navigation, Domestic / Tourism.
Time to implement	Short term (5-25 yr).
Administration level	All three levels: National, regional, local National: Framework for intervention and guidance for local decision making Coastal Sediment Cell units and sub-cell units: definition of measures for coastal protection Local authorities: coordination between land use planning and risk mapping.
Case studies	The Basque Climate Change Mitigation Plan contains measures for upgrading the network of tide gauges and numbers of oceanographic stations located on the coast (data collection sea level, temperature, intensity and direction of waves, wind ...), promoting and supporting observation systems and control, and increasing the systematization of the observations.
Reference	Cooper, N.J. and Pontee, N.I. (2006) Appraisal and evolution of the littoral [`]sediment cell’ concept in applied coastal management: Experiences from England and Wales. Ocean & Coastal Management, 49(7-8), p.498 - 510. DEFRA (2009) Appraisal of flood and coastal erosion risk management.A Defra policy statement, Lon don: Department for Environment, Food and Rural Affairs (DEFRA). Environmental Agency (2009) Investing for the future. Flood and coastal risk management in England. A long-term investment strategy., London. Eurosion (2004) Living with coastal erosion in Europe: Sediment and Space for Sustainability. A guide to coastal erosion management practices in Europe. Service contract B4-3301/2001/329175/MAR/B3 “Coastal erosion – Evaluation of the need for action,” European Commission. Government of Pais Vasco (2008) Action plan of pais Vasco against climate change (2008-2012). Regional office for climate change. Government of Pais Vasco.

	http://www.ingurumena.ejgv.euskadi.net/r49-11293/es/contenidos/plan_programa_proyecto/plan_cambio_climatico/es_cc/adjuntos/pvlcc.pdf Hutchison, J. et al. (2006) Adapting to Changing Coastlines and Rivers. Milligan, J., O'Riordan, T. and Watkinson, A. (2006) Living with a changing coastline: Exploring new forms of governance for sustainable coastal futures. O'Connor, M.C. et al. (2009) Practice versus policy-led coastal defence management. Marine Policy, 33(6), p.923 - 929.
Related to REFRESH-Measure	M409

Drought Management

Measure Number	SA12
Description	Drought management and water conservation plans are planning instruments containing measures aimed at temporary and permanent reduction of water consumption or use. They help to identify and reduce societal vulnerability to drought by improving drought preparedness and reducing drought impacts. Drought and water scarcity knowledge systems capture, manage, analyze and display relevant meteorological, hydrological, agro-technical, social and other data. This information can help to better forecast drought events and their associated impacts.
Measure category	Support action
Measure sub-category	Magement plans
Climate threat	Not enough water (scarcity & droughts)
Link to vulnerability	This measure addresses all drought relevant indicators, in particular water stress impact indicator via the sensitivity pressure indicator management practices.
Expert and stakeholder judgement	The stakeholders agreed that the drought management plans and the water conservation plans represent tangible and risk-free solution, pointed to the high benefits even in case of less pronounced climate change impacts. The measures have been considered a high priority for the EU policy makers.
Qualitative assessment based on literature review	Droughts are extreme events at the lower bound of climate variability: episodes of prolonged absence or marked deficiency of precipitation. Because precipitation replenishes soil moisture, groundwater aquifers, and surface streams, any deficit in input is eventually felt down the hydrological cycle, giving rise to what is called soil, groundwater and hydrological drought. Failed replenishment sets off 'stress signal' which quickly spread beyond the initially affected area, community or sector. The impacts of droughts are particularly austere when the 'below than usual' precipitations exacerbate already existing water scarcity that may be a result or arid- or semi-arid climate conditions or demand induced overexploitation of the water resources. The growing world population, unsustainable practices and inefficient allocation of water threat to induce and/or intensify water scarcity with disastrous consequences for environment and societies. The reduced water availability and increasing demand for water in agriculture, energy production and by households will – in many places already is – create stress the communities have to learn to live with. Drought management and water conservation plans (DM/WCP) are planning instruments usually supplementing river basin or emergency management plans, based on or responding to realistic scenarios of drought-induced, and thus temporary, or permanent water shortages. In principle, these planning instruments may have different forms and legal background, their content is similar though and that is the reason why they are addressed jointly in this fact sheet. Ideally, the DM/WCP should contain quantitative and measurable targets of water conservation, and set of measures to achieve these targets, prioritised according to their

performance and implementation costs. A prerequisite of a good drought management plan is i) a in-depth knowledge about the pattern of water uses and their welfare values, ii) medium- to long-term projection of climate variability and – change, and iii) drivers influencing water demand in the water-intensive economic sectors and public water consumption. The DM/WCP should contain a number of water demand and – supply management option (WDM and WSM). Demand-led policies and measures control and rationalise water uses and/or services (Lallana, Krinner et al. 2001; ESCWA 2002), and interventions affecting the timing of water use or provision, equitable allocation, and waste reduction (ESCWA 2002; Brooks 2006). Supply-led measures aimed at increased water provision in order to meet the demand. (Please note that this fact sheet concentrate on DWCP as a planning instrument, the single WDM and WSM measures are described in other fact sheets).

Detailed discussion of the DM/WCP can be found in Xerochore (2010). Although the plans may (and should) be developed at various administrative (municipal, irrigation district, provincial, regional) levels and for different economic sectors, they should be connected to the river basin management plan. At the national level, the drought and water conservation plans usually describe the normative framework, organisational structure and horizontal policy instruments (such as water abstraction licensing and pricing), the drought emergency declaration procedures, high-level policy targets and available resources. The large scale water transfer projects are usually defined at this level.

At the regional or river basin level the drought management plans should indicate regional drought triggers & indicators, drought risk and vulnerability, long-term interventions for reducing drought vulnerability, drought risk mitigation options per sector and drought severity level, allocation of tasks among regional actors, criteria for developing drought management plans at the water supply system level, cooperation scheme with the civil protection agency, processes for plan review.

In order to improve preparedness and to mitigate the impacts of increases in drought events, different regional drought management centres have been established in the past two decades. The *National Drought Mitigation Center* was established in the United States in 1995. In 2003, as a consequence to the projects ASTHyDA and ARIDE (Analyses of the Regional Impact of Droughts in Europe), the European Union founded its *European Drought Centre* as a long-term joint effort, and then in 2006, Slovenia is selected to host the *Drought Management Centre for Southeastern Europe* (DMCSEE). As this region will potientialy be the most affected by droughts increase and won't have the same problematic of Europe, it is necessary forSoutheastern Europe to have its own centre. Since 2007, the opening of a centre for Central Asia is also planned for the coming years.

According to the DMCSEE, a drought management centre has 8 main objectives:

1. To assess the data available for effective drought monitoring and early warning system,
2. To evaluate and select the most effective and reliable indices and indicators for drought assessment
3. To conduct a drought risk assessment
4. To identify the specific training needs
5. To develop and implement a data and information delivery system on drought management.
6. To develop a comprehensive network of experts and institutions to assist the drought centre

	7. To ensure communication and user feedback 8. To ensure sustainable functioning and operations Regional centres are especially important in the context of drought management to use available regional data and to develop local, specific strategies. Reliable information on the extent and impacts of water scarcity and droughts is indispensable for decision-making at all levels. Information systems are especially useful in this context as they combine various data sets and information into a single database or map to provide a holistic picture. Within the EU, the quality of information systems varies with each country but there are common difficulties, namely: statistics on the magnitude of demand and withdrawal are often estimated rather than based on data leading to high uncertainty, adequate historical datasets are rare, and there is a lack of agreed terminology which leads to discrepancies in the data compilation and analyses (Kristensen, 2010). The use of information systems in other EU policy arenas (e.g. EUNIS on species, habitat types and sites, WISE on water and DISMED on desertification in the Mediterranean) have helped to highlight sensitivity and increase awareness.
EU Policies concerned and institutional process	Water Framework Directive, Communication on WS&D, Communication on Disaster Response Capacity The European Water Framework Directive (WFD), the flagship of the EU Water Policy recognised droughts as potential threats which may undo the efforts to achieve good ecological status of the Community water bodies. Yet drought mitigation is but the last among the aims underpinned in the Article 1 of the Directive, and the one which is least substantiated. The 2012 Review of the WFD is seen by many as an opportunity to increase emphasis on water scarcity and droughts. In order to address the issue of water scarcity and droughts in the EU, in 2007 the European Commission (EC) issued a Communication 'Addressing the challenge of water scarcity and droughts in the European Union'5. The communication lists a set of policy options, implementable as a concerted EU action, to increase water efficiency and water savings, and to improve drought preparedness and risk management. The European Union's efforts in disaster risk reduction intensified with the EC Communication on Disaster Response Capacity (EC 2008). This Communication highlighted the need for stepping up the Community capacity and effectiveness to respond to disasters, within and outside the EU. To do so, the EC proposed several tangible means for a better coordination of various EU/Community policies, instruments, services and players (at national, European and international levels). While the Communication focuses on the response to disasters, it acknowledges that a comprehensive approach to disaster management is needed comprising risk assessment, forecast, prevention, preparedness and mitigation. The European Union has adopted the United Nations Convention to combat desertification in countries seriously affected by drought and/or desertification. The aim of the Convention, which was signed in 1994, is to combat desertification and mitigate the effects of drought in those countries experiencing serious drought, particularly in Africa, through international cooperation and effective action at all levels. (see Council Decision 216/98/EC of 9 March 1998 on the conclusion, on behalf of the European Community, of the United Nations Convention to combat desertification in countries seriously affected by drought and/or desertification, particularly in Africa).

[5] COM/2007/0414 final

Character of measure	Preventing, preparatory, reactive
Sector(s) affected	Water management, Agriculture, Energy, Industry, Forestry domestic/Turism
Time to implement	Short term (5-25 yr)
Administration level	National, Regional / River basin
Examples	DMP help preventing new additional water supply options and minimize the environmental impacts and costs associated with developing new supplies. The basic elements and contents of DMPs may include: • General basin characteristics under drought conditions • The history of droughts in the river basin • Characteristics of droughts within the basin • Drought warning system implementation • Programme for preventing and mitigating droughts linked to indicator systems • Organisational structure of the DMP (identification of competent entity, committee or working group to identify drought impacts and propose management) • Update and follow-up of the DMP • Public supply specific plans • Prolonged drought management. Where appropriate, a section should be dedicated to 'prolonged drought' as required in article 4.6 WFD
Case studies	Iterative research projects at the US National Science Foundation produced a drought planning process that was first published in 1990, Since then, it has been revised and updated several times to reflect greater state, national, and international experience in drought planning. Greater emphasis on mitigation and preparedness, recent workshops on drought planning, and a methodology for conducting risk analysis have also helped reshape the drought planning methodology. The process is written for application at the state level, but the methodology is generic and can be adapted to any level of government in any country.
Reference	Ecologic, EEA (2009)Report on good practice measures for climate change adaptation in river basin management plans European Council (2011) Council conclusions on Integrated Flood Management within the European Union 3085th JUSTICE and HOME AFFAIRS Council meeting, Brussels, 12 May 2011. Hungarian Climate Change Action Plan 2008-2025, http://www.kvvm.hu/cimg/documents/nes080214.pdf Johnson, R. (2000) GIS Technologcy for Disasters and Emergency Management. An ESRI White Paper. http://www.esri.com/library/whitepapers/pdfs/disastermgmt.pdf Kristensen, P. (2010) How big is the problem with Water Scarcity & Droughts in the EU? – available data and indicators. Water Scarcity and Droughts Stakeholder Meeting, 27 April 2010. Presentation on behalf of the EEA. http://ec.europa.eu/environment/water/quantity/pdf/stakeholders/EEA_WSD_presentation.pdf M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds. Cambridge

	University Press, Cambridge (2007) Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Chapter 3, UK, pp 186-188 Potsdam Institute for Climate Impact Research (2009) Cross-comparison of climate change adaptation across regions (NeWater) http://www.newater.info/index.php?pid=1053 Reference Website of the European drought centre http://www.geo.uio.no/edc/downloads/edc_poster_23.02.06_A1.pdf Wilhite, A.D., Hazes, J.M., Smith, H.K. The basics of drought planning. National Drought Mitigation Center. http://www.ose.state.nm.us/water-info/NMWaterPlanning/regions/MiddleRioGrande/App12-13-6-10StepsOfDroughtPlanning.pdf UNCCD, OSCE : Dialogue on establishing a Drought Management Centre in Central Asia in the Context of the United Nations Convention to Combat Desertification Water Conservation and Contingency planning in Texas, http://www.cityofallen.org/departments/community_svcs/pdfs/aCombined%20Wtr%20Cons%20&%20Drought%20Plan.FINAL.071408.pdf Bortone, G., Tiyiano, D. (2005) Water conservation and water protection planning in Italy. Environmental Directorate. Emilia-Romagna Region. http://arid.chemeng.ntua.gr/Project/Uploads/CyprusConf/Session_A/PDF/Bortone_G.,_Draghetti_T.-Water_conservation_and_water_protection_plan_in_Emilia-Romagna.pdf Website of the DMCSEE: http://www.dmcsee.org/en/home/ Website of the National Drought Mitigation Center: http://www.drought.unl.edu/about.htm Xerochore (2010) Extended Guidance Document after Conference on Drought Management and Policy Options. The Xerochore project http://www.feem-project.net/xerochore.
Related to REFRESH-Measure	M191

Water conservation and abstraction plans (WCAP)

Measure Number	SA13
Description	Water conservation and abstraction plans (WCAP) are multi-year plans which detail how the authorities responsible for granting water abstraction licenses, will manage water resources at catchment scale. The WCAP work by assessing the availability of water resources on a scientific basis and then taking stock of all water needs including water demand of ecosystems in the future. The aim is to provide a framework for a licensing strategy which aids the sustainable management of water resources on a catchment scale. This can include consumptive (e.g. agriculture) and non- consumptive uses (abstraction for cooling purposes) Licenses are time-limited requiring that WCAP are regularly updated and progressively integrated in other strategies and programs related to water. It is also important to elaborate a communication plan devoted to an efficient use of water consistent and coordinated with the organizations working on the issue.
Measure category	Support Action
Measure sub-category	Managment Plans
Climate threat	Not enough water (scarcity & droughts)
Link to vulnerability	Addresses water stress impact indicator via state sensitivity indicator water use and pressure indicator management practices.
Expert and stakeholder judgement	Subjected to a fast track assessment, the stakeholders assigned a medium to high priority and urgency for the measures regarding the catchment abstraction management strategies. Moreover it has been considered almost completely free from negative side effects. Stakeholders considered the measure cost effective for the potential high benefits achieved with relatively low costs depending on implementation. The success of this measure, i.e. the socio-cultural acceptance of recommendations to save water, may be higher when an actual threat is perceptible, e.g. during a drought, thus it highly depends on the current weather conditions.
Qualitative assessment based on literature review	Reliable projections of future water needs are clearly a necessary pre-condition for planning and the development of climate change adaptation strategies (e.g. Arranz and McCartney, 2007). As climate change can lead to significant changes in average precipitation, average river discharge, average soil moisture, and groundwater recharge these needs might not be longer satisfied. The return periods of droughts with 1-in-50 years drought might become 1-in-10 years drought. In addition, models project that availability of freshwater resources may shift in space and timing. In combination with unchanged or increasing demand for water, this will probably lead to augmentation of water scarcity (EEA 2009). Water needs comprise water for humans, e.g. drinking water and water for production and cooling, and water for nature, i.e., environmental flows. In order to achieve good ecological status of rivers, as required by the European Water Framework Directive, it is crucial to set appropriate environmental flows (Acreman and Dunbar, 2004). Hence, planning must take into account future changes in regulation, water use and climate, e.g. for operating

strategies of dams and reservoirs (IUCN, 2003). Adaptation strategies for Europe must also take into account virtual water (Hoekstra, 2011; Hoekstra and Hung, 2005). Increasing water stress outside Europe will also affect the EU's supply with food and goods since Europe imports a considerable fraction of these commodities, in particular from regions facing heaviest threats by climate change and socio-economic development, e.g., population growth (EEA, 2010)

The European Commission recognised the urgency to address the issue in its communication on water scarcity and droughts (COM/2007/414 final). Seven policy options were identified for tackling water scarcity and drought issues including "improving drought risk management" and "fostering the emergence of a water-saving culture in Europe". WCAP respond to that. The availability of water resources for abstraction is assessed through a WCAP process. This determines how much water is reliably available on a catchment by catchment basis. By taking into account the amount of water already licensed for abstraction and how much water the environment needs, one can determine how much water is potentially available for further abstraction (Environment Agency, 2008).

WCAP are seen as a proactive and effective approach to tackle water scarcity and drought problems. The measure shows evident benefits in all areas that are threatened by water scarcity and impacts of droughts (Environment Agency 2008, 2010). It is typically a no-regret measure, especially with regard to the preparation of hazard maps for the general population and for public authorities (RP Kassel 2010a). The positive adaptation benefits can be realized if the measure is implemented. Linking these results with other plans and programmes is mandatory (e.g. Waterwise, 2011).

Within abstraction plans, thermal load plans should be taken into account during severe drought events. River basins with high water abstraction for cooling purposes need to address the impacts of discharging thermal water, especially in times with low water flow due to droughts. Besides the direct effects of cooling water on water temperature, cooling water can destroy flora and fauna such as larvae and phytoplankton and zooplankton, fish egg due 1) higher temperatures and 2) reduced river flow due to abstraction. Both lead to an increase in oxygen consumption. A decrease in oxygen also plays a significant role due to the warming of water temperatures (Projektgruppe Wärmelastplan Tideelbe, 2008. Some river basins (Elbe, Rhine) in Germany, for example, have already developed thermal load plans due existing discharge of cooling water as well as future plans to build additional power plants.

During drought events, abstraction strategies should plan to restrict the discharge of cooling water into rivers and also consider placing restrictions on abstraction quantities. This will help to avoid the aforementioned problems associated with cooling water.

WACP should be accompanied by information and educational programmes in all water use sectors. They should aim at raising public awareness of water conservation, promoting efficient water use and water-saving technologies, and more generally, inducing a change in water consumption habits towards a water-saving behaviour. Often several target groups are addressed, such as private households, local authorities or SMEs, with a strong emphasis on shared responsibility.

Such campaigns can make use of a wide range of information channels as the classic media (TV, newspapers, radio), internet, leaflets, billboard advertising, advertising in public and private transport systems as well as educational programs in schools and kindergartens.

Information programmes usually support other water conservation measures by promoting water-saving devices and technologies like low-flow shower heads, low-flush toilets, water saving clothes washers and dishwashers, greywater use, or rain water harvesting.

	However, there are still large uncertainties in relation to the development of WCAP, which urgently need to be addressed in future research, e.g.: 1) There is still limited knowledge and a lack of bio-physical data regarding the adequate assessment of environmental flows to maintain eco-system functions as they cannot be defined only by water quantity but must take into consideration the entire flow regime (Acreman and Dunbar, 2004; Arthington et al., 2006). 2) Projections of future water demands for human activities are still highly uncertain because high quality data regarding current water use patterns are missing. This applies in particular for developing countries, where dramatic changes are to be expected. For example, the assessment of current water consumption is much more uncertain than the assessment of water withdrawals due to a lack of data (Alcamo et al., 2007). 3) Dynamics of water use patterns are highly dependent on global trade mechanisms, which are likely to change considerably in the future. However, there are only few studies examinating the implication of virtual water trade on water scarcity and supply security in Europe. 4) There is still a high uncertainty in relation to climate impacts on the regional level.
Costs	The costs and benefits of such plans is hard to judge or quantify as they are mostly depending on the detailed action /measures taken.
EU Policies concerned and institutional process	Water Framework Directive, Communication on Water Scarcity & Droughts, Directive on the quality required of shellfish waters, Rural Development Regulation The EU policies and strategies throughout which the measure could be promoted is the Water Framework Directive and the Communication on Water Scarcity & Droughts. Minimizing the sensitivity to water scarcity and droughts will also impact the implementation of the Common Agricultural Policy (CAP), Habitat Directive and Water Framework Directive (WFD). WCAP contribute to the WFD by: • providing a water resource assessment (today and in the future) of rivers, lakes, reservoirs, estuaries and groundwater referred to as water bodies under the WFD; • identifying water bodies that fail flow conditions expected to support good ecological status; • preventing deterioration of water body status due to new abstractions; providing results which inform River Basin Management Plans (RBMPs). Under Annex III of the WFD it is required to develop forecast on future water needs for water users. These forecasts have to be reviewed every 6 years under each implementation cycle of the WFD. Water Abstraction control through the development of WCAP is one of several 'basic measures' (Article 11) alongside measures to promote efficient and sustainable use of water. Thermal issues related to abstraction and recharge is governed under Directive 2006/113/EC on the quality required of shellfish waters. The communication elements could be important against the backdrop of the EU White paper on Adaptation, to raise awareness of the role of the European Union in adaptation, to support national, regional and local actors to adapt. Follow-up or supplement to the mitigation and energy savings campaign 'You Control Climate Change' (2006-). There have been a number of "European Years", beginning in 1983 which have been designated and run directly by the European Union and its Member States; however, some (such as 2005) have been designated and run by the Council of Europe. Each year has a

	specific topic and adaptation to CC or resource efficiency could be added. Other possibilities are activities like the "Green Week" or the "European Green Capital" with which the European Commission supports awareness raising and dissemination. LIFE+ is an EU funding programme supporting environmental projects. The funding form LIFE+ includes projects like e.g. environmental management, industry and production, urban environment and quality of life. One component of the programme is the "Life+ Information and Communication". The programme supports awareness raising compaigns and communication actions inter alia on water issues. Furthermore this measure can be promoted by the Rural Development Regulation thats follows the theme improving the environment and the countryside.
Character of measure	Preventive, Preparatory, Reactive
Sector(s) affected	Water management, Agriculture, Domestic / Tourism, Energy, Industry
Time	Short term (5-25yr)
Admin level	Regional, river basin, company
Case studies	Only case studies for information programmes which should form an integrated part of the WCAP have been identified. A range of case studies report that information programmes, in addition to or promoting other measures, can lead to a considerable reduction of water consumption: 1. Over the course of about 10 years, the ***Berlin*** Water Works succeeded in considerably reducing water losses due to breakages in the pipe system. Household water consumption was halved, from about 250 liters per capita per day to about 125 liters per capita per day due to implementation of different measures (reducing water losses due to breakages in the pipe system, metering, and awareness campaigns). Similarly, drinking water consumption was reduced by about 40 percent. The awareness campaigns included different measures such as distribution of an information leaflet *'Berlin saves water'* to 1 million households in early 1988; Campaigns in the public and private transport systems, like placing the slogan 'Berlin saves water'; Public information about the technical possibilities for water saving (equipment, apparatus), instruction in public institutions (kindergartens and schools); etc. 2. "Saving Water City" ***Zaragoza*** (Spain). The project has shown that it is possible to deal with the shortage of water in cities, using a cheap, ecological, fast and contentious-free approach, by increasing efficiency in consumption. The most important lesson to be learnt is that the shared responsibility between the main players (manufacturers, retailers, consumers, distributors, plumbers etc) has managed to create a new synergy which favors water-use efficiency. 168 educational establishments, 428 teachers and 70,000 students are directly participating in the campaign's Educational programme. 90% of the media in Zaragoza are collaborating directly in the campaign. An annual reduction in domestic consumption of 5.6% was achieved. The campaign focused on simple technological changes to achieve a reduction in water use like acquisition of new water-saving sanitary equipment, installing of water-saving mechanisms in old appliances, introducing individual household hotwater meters in buildings with communal service, repairing leaks, and reutilizing domestic water.

3. A highly successful public education campaign has been undertaken in ***Israel***, especially during drought-ridden years. Citizens were encouraged to use water-saving devices, repair leaking faucets and report leaks in the public sector under the motto "Every Drop Counts." Water conservation was also integrated into the school curriculum, ensuring that Israeli youth grow up with both an awareness of the problem and the knowledge and tools needed to conserve this scarce resource. Data show that at the height of the water conservation campaign, in 1990/1, average per capita consumption in the municipal sector was significantly reduced. Urban water consumption decreased from 85 cubic meters per capita per year to 70 cubic meters between 1989 and 1991; domestic water consumption was reduced from 60 cubic meters per capita per year to just above 50 cubic meters.

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Linked to R	M041, M042, M043, M084, M085, M086, M087, M088, M090, M093, M095, M096, M097,M098, M099, M100, M247, M248, M255, M256, M258, M259, M260, M261, M262, M299, M302, M304, M306, M308, M313, M314, M315, M402, M403, M429, M430, M431, M432, M433, M434, M435,

IMPLEMENTATION OF A CROSS-SECTORAL ADAPTATION AND RISK AVERSION STRATEGY

Measure number	M14
Description	The measure is aimed to establish national, statewide or regional aversion strategy for all sectors that are related to climate change adaptation.
Measure category	Support action
Measure subcategory	Management plans
Climate threat	Deteriorating water quality & biodiversity, Too much water (flooding, sea level rise, coastal erosion), Not enough water (scarcity & droughts)
Link to vulnerability	The measure as a holistic approach is adressing all impact indicators that are related to climate change via pressure indicator changes in the management practices.
Expert and stakeholder judgement	Subjected to a fast track assessment, the stakeholders assigned a high priority and urgency for the measure regarding cross sectoral adaptation.
Qualitative assessment based on literature review	The reduction of greenhouse gas emissions and the adoption to the impact of climate change continues to be a priority issue in national, European and international environmental policy. Consequently, a national aversion strategy, also refered to as national adaptation strategy (NAS) follows the overarching objective to reduce the vulnerability and maintain and improve the adaptability of natural, social and economic systems. The national adaptation strategies in the EU are based on a common European framework enabling Member States to plan and communicate their adaptation efforts. The European Commission's White Paper from April 2009 observed, with an aside to the requirement under Article 4 of the United Nations Framework Convention on Climate Change for parties to the Convention to prepare national adaptation strategies. In September 2009 the Commission published a set of guidelines for the design of regional climate change adaptation strategies in an attempt to rally the development of more national adaptation strategies within the EU. Prior to the White Paper a number of Member States had already adopted National Adaptation Strategies (Denmark, Finland, Germany, France, Hungary, Netherlands, the United Kingdom, Sweden and Spain). Evenso countries are still at different stages most have allready taken steps to evaluate the impacts of climate change. The EEA (2011) gives a good overview over progress towards national adaptation strategies in EU27. National Strategies are often based on the principles of cooperation, risk aversion, integration and sustainability. Evenso general objectives between the member states differ, common goals can be recognized: (i) the identification and communication of dangers and risks, (ii) creating awareness, (iii) mainstreaming the climte change topic in private, business and public planning activities, (iv) debate and implement adaptation measures (see e.g. Federal Government of Germany 2008).

	National or statewide strategies can also be found in countries that are not part of the European Union (e.g. Climate change adaptation in Norway 2008, State of California 2009). Also different impacts on other systems like biodiversity, natural eco-systems, etc. appear at different level depending at the separate measure.
Costs	For the political process of establishing an adaptation strategy the costs are relative low. Costs at different level occur for the implementation of adaptation measures. The costs and benefits of adaptation measures are very different for the several measures (i.e. Agrawala & Fankhauser 2008).
EU Policies concerned and institutional process	This measure is part of the current policy developments in the area of adapation to climate change and will partly result in a EU adapation Strategy towards Climate change in 2013 latest.
Character of measure	Preventing, Preparatory
Sector(s) affected	All sectors affected
Time	Short term (5-25 yr)
Admin level	National (or state), Municipality/company
Reference	Agrawala, S., Fankhauser, S. (Ed.) (2008) Economic Aspects of Adaptation to Climate Change – Costs, Benefits and Policy Instruments. OECD, Paris. Commission of the European Communities (2009) White paper. Adapting to climate change: Towards a European framework for action. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0147:FIN:EN:PDF EEA (2011) Progress towards national adaptation strategies (NAS). http://www.eea.europa.eu/themes/climate/national-adaptation-strategies Federal Government of Germany (2008) German Strategy for Adaptation to Climate Change. adopted by the Federal Cabinet on 17 December 2008. http://www.bmu.de/files/english/pdf/application/pdf/das_gesamt_en_bf.pdf. Norwegian Government (2008) Klimatilpasning i Norge. Regjeringens arbeid med tilpasning til klimaendringene. http://www.regjeringen.no/upload/MD/Vedlegg/Klima/Klimatilpasning/Klimatilpasning_redegjorelse150508.pdf State of California (2009) California Climate Adaptation Strategy. http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF United Nations (1992) The United Nations Framework Convention on Climate Change http://unfccc.int/resource/docs/convkp/conveng.pdf

WATER SAVING IN BUILDING CODES

Measure Number	SA15
Description	New national standard for sustainable design and construction of new homes, which places strong emphasis on water conservation in households.
Measure category	Support action
Measure sub-category	Regulatory
Climate threat	Not enough water (scarcity & droughts).
Link to vulnerability	This measure addresses impact indicator water stress via sensitivity state indicator water use and sensitiviy pressure indicators water use efficiency.
Expert and stakeholder judgement	The stakeholders recognized some value to the water saving in building codes, but found not easy the implementation of this measure. The measure has not been considered urgent especially because of the scarce value that the experts and stakeholders gave to its flexibility and feasibility. Efficiency and effectiveness of the measure have been highly discussed and several perplexities rose, especially in terms of costs and benefits comparison.
Qualitative assessment based on literature review	Energy and water are essential, interdependent resources, while the buildings sector is end-user of both. Building codes are the regulatory instrument determining the resource use and other performance characteristics of buildings. With reference to building codes Koeppel and Ürge-Vorsatz (2007) find that if implemented properly they are both highly effective and normally also cost-effective in reducing greenhouse gas emissions from buildings. At the European level the recently recast Energy Performance of Buildings Directive (EPBD) (2010/31/EU) regulates the energy use of buildings, adopting an integrated approach to different aspects of energy use (eceee 2010). The EPBD and the recast EPBD contain (eceee 2010): • An integrated methodology for measuring energy performance • Minimum energy performance standards for new buildings • Energy certification and advice for new and existing buildings • Inspection and assessment of boilers and heating/cooling systems • The introduction of the concept of 'nearly zero energy building'. From 2018 public authorities can newly buy or rent only such buildings. The issue of the interconnectedness of water and energy use is also relevant in the buildings sector. The term 'water-energy nexus' refers to the inextricably linked nature of water and energy resources (Rothausen and Conway 2011): supplying energy requires water and impacts water quality, while supplying water requires energy (US DE 2006). Furthermore, the water-energy nexus is deeply embedded within the context of climate change (Maas 2009).

	With reference to energy use in the water sector Rothausen and Conway (2011) indentify stricter water-quality standards, increasing demand for water, and the need to adapt to climate change parallel to reducing greenhouse gas emissions, as the main energy-use related pressures facing water management. A further significant issue is the determination of clear boundaries of the water sector (Rothausen and Conway 2011). Maas (2009) assesses urban water services in terms of their energy use, and distinguished three main ways through which energy integrates into the urban water use cycle: • Indirect energy (municipal energy to pump and treat waste and wastewater) • Direct energy (energy end-use to heat water, household purification and water softeners) • Embedded energy (to manufacture chemicals used for the treatment of water and wastewater) Ways to increase energy efficiency in urban water management include the installation of more efficient equipment (e.g. water efficient fixtures), the adoption of water conservation measures and upgrading infrastructure (Maas 2009, US GAO 2011). At the same time the implementation of these measures is obstructed by barriers. US GAO (2011) identifies five key groups of to improving energy efficiency of the urban water life cycle. These include (US GAO 2011): 1. Costs associated with the technologies 2. Inaccurate water pricing 3. Barriers associated with how water utilities operate 4. Competing priorities at drinking water and wastewater facilities 5. Lack of public awareness about the energy demand of the urban water lifecycle. At the same time water availability is an important factor in meeting growing energy demand. Water is used in energy-resource extraction, refining and processing, transportation, as well as is an integral part of electric-power generation (US DE 2006). Different energy generation technologies have differing water use characteristics. Hydroelectric generation uses water directly, while water is used for cooling and emissions scrubbing in thermoelectric generation (US DE 2006). Some thermoelectric power plants return the withdrawn water to the source with changes in quality (for example changes in temperature), while others withdraw much less water but consume the whole amount through evaporative cooling (US DE 2006). As for efficiency, natural gas-fired power plants are the most water-efficient conventional mode of electricity generation (Glassman et al. 2011). Coal and nuclear consume two and three times more water than gas-fired plants per unit of electricity (Glassman et al. 2011). The perceived water use of hydroelectric generation depends on assumptions on water diversion and evaporation rates of human-made reservoirs, ranging from zero to substantial water consumption (Glassman et al. 2011). Among renewable technologies geothermal, concentrating solar are extremely water-intensive, while wind and solar PV are characterized by low water demand (Glassman et al. 2011). The large-scale mitigation technology of carbon capture and storage may double water consumption for fossil fuel generation (Carter 2010, Glassman et al. 2011). Furthermore, in terms of transportation fuels, first-generation biofuels (irrigated soy and irrigated corn) are characterized by very large water demand (Glassman et al. 2011).
EU Policies concerned and	Eurocodes, WS&D-policy Adaptation can be integrated in the Eurocodes of buildings (Commission Recommendation on Eurocodes) as well as into the design of new urban development. Further all technical

institutional process	infrastructure funded by the Commission could be linked to such codes. Other relevant EU policies: Communication on Resource efficiency.
Character of measure	Preventing/Reactive
Sector(s) affected	Industry, Water management, Domestic / Tourism
Time to implement	Short term (5-25 yr)
Administration level	National
Case studies	The Code for Sustainable Homes, launched in the United Kingdom in December 2006, is a new national standard for sustainable design and construction of new homes, which places strong emphasis on water saving in households. The Code measures the sustainability of a new home against nine categories of sustainable design, rating the 'whole home' as a complete package. The Code uses a 1 to 6 star rating system to communicate the overall sustainability performance of a new home. The Code sets minimum standards for energy and water use at each level and, within England, replaces the EcoHomes scheme. Code level 1 allows for internal potable water consumption of 120 litres per day and code level 6 for merely 80 litres per day.
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COMPULSORY WATER RESTRICTIONS AND RATIONING

Measure Number	SA16
Description	Water restriction limit certain uses of water for example irrigation of lawns, car washing, filling swimming pools, or hosing down pavement areas. Water rationing include usually temporary suspension of water supply, or reduction of pressure below that required for adequate supply under normal conditions. Rationing is associated with equitable distribution of critically limited water supplies in a way that ensure sufficient water is delivered to preserve public healthy and safty. Both rationing and restriction that may be of temporal or permanent character.
Measure category	Support action
Measure sub-category	Regulatory
Climate threat	Not enough water (scarcity & droughts).
Link to vulnerability	This measure addresses water wtress indicator via state indicator water use and pressure indicator management practices In a long term it also might have effect on the driver indicator preferences.
Expert and stakeholder judgement	The experts and stakeholders recognized some value to the water restriction and consumption cuts, but they found not easy, and not free of ethical and social risks, the implementation of this measure. Some perplexities are risen about the effectiveness of this strategy. The structural adoption of this strategy in terms of adaptation has been scarcely appreciated, preferring a more responsible and efficient water management. The urgency and priority of the measure is evaluated as high.
Qualitative assessment based on literature review	Water restrictions and, to a lesses extent, rationing are frequently used especially in situations of temporary water shortages (drought) but not only. For example, the 2008 drought in Australia compelled authorities to impose water restrictions that affected 75 per cent of Australians (Grafton & Ward 2008). Restrictions can limit the water volume, such as the time when it can be used and its purpose. Compulsory water restrictions can produce significant water savings in a short time, comparable only to significant price increases (Renwick & Green 2000). For that reasons, the restrictions are favoured over economic instruments (e.g. water pricing) in situation in critically limited water supplies. Another argument brought in favour of restriction is the low water price elasticity especially with respect to the residential, indoor water uses. Low price elasticity means that increasing the water price will not reduce the demand or only slightly (Renwick & Green 2000; Grafton & Ward 2008). The residential water use is in fact characterised by low price-elasticity6 (Conley 1967), particularly for indoor water use. It has been shown that the elasticity depends on

[6] Price elasticity of demand is expressed as a percentage change in water demand in response to a given percentage change in price. For example, an elasticity of – 1 means that a 10 per cent increase in price results in a 10 per cent reduction in demand (Hughes *et al.* 2008).

	household income (higher price elasticity has been observed in low-income households), family size, age and other demographic characteristics. The outdoor consumption is usually more (less) price-elastic in wet (dry) seasons (Mansur & Olmstead 2007). The results of studies vary considerably, to a large extent as a result of differences in methodologies applied, data quality and aggregation (Dalhuisen et al. 2001; Productivity Commission 2008). Dalhuisen et al. (2003) analysed 64 studies with 314 (mainly short-run) price elasticity estimates ranging from – 7.47 to + 7.90 (mean value –.41, median –.35). Most of the estimates fall within the range between 0 and – 1, thus providing evidence which supports the hypothesis of limited price elasticity. While a number of studies focus on the price-elasticity, less is known about the income elasticity, or namely, how the demand reacts to the increases in income. As Dalhuisen et al. (2001) observes, a successful mix of demand management options decreases households' expenses which, as an unintended outcome, in case of positive income elasticity may translate into higher water consumption. In addition, studies have shown that residents are willing to pay for improved water services and to avoid compulsory water rationalising and restriction (Barrett 2004). The willingness to pay, however, may be significant only to avoid more severe restrictions (Hensher et al. 2006). The compulsory restrictions such as a sprinkler ban can be circumvented by higher labour input (i.e., by using hand-held hoses and buckets) which can also be priced, in this case by foregone leisure time/activities with welfare effects (Brennan et al. 2007). On the other hand, compulsory restirction are associated with welfare losses and significant enforcement costs, both poorly researched and documented (Hughes et al. 2008). It is widely acknowledged that water restrictions which equally affect all consumers are not economically efficient (Garcia-Valinas 2006; Brennan et al. 2007; Grafton & Ward 2008; Olmstead & Stavins 2009). The diverse consumers hold different marginal values for the same use and these differences are amplified across different water uses. Administratively imposed water tariffs do not allow shifting to uses with higher marginal value, with significant losses of welfare. According to the Production Commission (2008) the order of magnitude of annual costs to Australian households due to water restriction was of some 'multi-billion dollars'. These losses include structural damage to buildings, deteriorated status of lawns, costs of new watering systems, and structural changes of the gardens. Bauske and Landry (2007) report significant losses to the urban agriculture sector when stricter restrictions are imposed. Urban agriculture produces an estimated 20 per cent of the global food supply (Raschid-Sally & Jayakody 2008). Half of this is produced using wastewater, with consequent, significant health risks, including cholera outbreaks.
EU Policies concerned and institutional process	Water Framework Directive, Communication on water scarcity and droughts. The Water Framework Directive can orient competent administrations towards water saving in general. Art 9 (water pricing) of the WFD can be implemented in combination with restrictions. Drought Management plans, which can also be subject to the Program of Measures normally include restrictions and methods for rationing in the case of drought events.
Character of measure	Reactive/ Recovery
Sector(s) affected	Industry, agriculture, Domestic / Tourism
Time to implement	Short term (5-25 yr).
Administration level	All three levels: National, regional/basins, and municipality/company.

Reference	Barrett, G. (2004) Water conservation: the role of price and regulation in residential water consumption. Economic papers 23: 271-285. Bauske, E. & Landry, G. (2007) Economic Impact of the Drought on Urban Agriculture Industries. University of Giorgia (US), UGA Centre for Urban Agriculture. http://apps.caes.uga.edu/urbanag/pubs/droughtImpact.pdf Brennan, D., Tapsuwan, S. & Ingram, G. (2007) The welfare costs of urban outdoor water restrictions. Australian Journal Of Agricultural And Resource Economics 51(3): 243-261. Conley, B. C. (1967) Price elasticity of the demand for water in Southern California. The Annals of Regional Science 1(1): 180. Dalhuisen, J. M., Florax, R. J. G. M., de Groot, H. L. F. & Nijkamp, P. (2003) Price and Income Elasticities of Residential Water Demand: A Meta-Analysis. Land Economics 79(2): 292-308. Dalhuisen, J. M., Florax, R. J. G. M., de Groot, H. L. F. M. & Nijkamp, P. (2001) Price and income elasticities of residential water demand. Tinbergen Institute Discussion Paper TI 2001-057/3. Ecologic, EEA (2009) Report on good practice measures for climate change adaptation in river basin management plans Garcia-Valinas, M. (2006) Analysing rationing policies: droughts and its effects on urban users' welfare. Applied Economics 38(8): 955-965. Grafton, R. Q. & Ward, M. B. (2008) Prices versus rationing: Marshallian surplus and mandatory water restrictions. Economic Record 84: S57-S65. Hensher, D. A., Shore, N. & Train, K. E. (2006) Water Supply Security and Willingness to Pay to Avoid Drought Restrictions. Economic Record 82(256): 56-66. Hughes, N., Hafi, A., Goesch, T. & Brownlowe, N. (2008) Urban water management - optimal pricing and investment policy under climate variability. ABARE research report 08.7. Canberra. Mansur, E. T. & Olmstead, S. M. (2007) The Value of Scarce Water: Measuring the Inefficiency of Municipal Regulations. NBER Working Paper No. W13513. Available at SSRN: http://ssrn.com/abstract=1021991. Olmstead, S. M. & Stavins, R. N. (2009) Comparing price and nonprice approaches to urban water conservation. Water Resources Research 45. Productivity Commission (2008) Towards urban water reform: a discussion paper. Productivity Commission Research paper, Melbourne. Raschid-Sally, l. & Jayakody, p. (2008) Drivers and Characteristics of Wastewater Agriculture in Developing Countries: Results from a Global Assessment. International Water Management Institute, Colombo, Sri Lanka. http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/PUB127/RR127.pdf Renwick, M. E. & Green, R. D. (2000) Do residential water demand side management policies measure up? An analysis of eight California water agencies. Journal Of Environmental Economics And Management 40(1): 37-55.
Related to REFRESH-Measure	M247

1 Annex 12: Minutes of the Stakeholder Workshops

1.1 Minutes of the 1st Stakeholder workshop

European Commission
Directorate-General Environment
Markets Team
ENV.F.2 (BU-5 00/122)

Minutes (Draft Version)
of the 1st Stakeholder Meeting
of the project
Climate Adaptation – modelling water scenarios and sectoral impacts
Contract N° DG ENV.D.2/SER/2009/0034

18 October 2010

CESR – Center for Environmental Systems Research
In co-operation with

CESR – Center for Environmental Systems Research,
Wissenschaftliches Zentrum für Umweltsystemforschung
Kurt-Wolters-Str. 3, D – 34109 Kassel, Tel.: +49 561- 804-3266, Fax: +49 561- 804-3176

1.2

Chair: Cornelius Laaser, Ecologic Berlin.

Annex A lists those present at the meeting.

Monday October 4, 10 a.m.:

Welcome and introduction to the project

Project officer **Jacques Delsalle (DG Env)** welcomes workshop participants. He presents his vision of the project's Integrated Assessment Framework (IAF) as part of a dialogue for the next generation RBMPs. In addition he highlights the importance of balancing stakeholder initiatives (national & local level) with this initiative of the Commission. The project is complemented with qualitative analysis provided by stakeholders.

1st session: General project overview

Martina Flörke (CESR) holds an introductory presentation on the project, providing project overview (C-Map). Rationale for stakeholder workshop:

- Identify and possibly fill knowledge gaps
- Compile stakeholder knowledge
- Evaluate the credibility and policy relevance of the results, e.g. adaptation measures.
- Evaluate the attitudes (for/against) of stakeholders regarding a particular measure.

She opens the floor to the stakeholders for their expectations regarding the project and this workshop, as well as inviting their comments.

Julian Wright (Environment Agency) asks for elaboration of the concept of stakeholder. Measures will be seen as very different (for/against) according to the group stakeholders come from. From the project officer's introduction he sees that the target is second cycle RBMP planning.

Martina Flörke says that this is why different stakeholders have been invited to the workshop, representing different sectors, e.g. agriculture and energy.

Jan Brooke (Inland Navigation Europe) reports her surprise that only 4 sectors are being dealt with, no focus on transport.

Jacques Delsalle says that this is related to the project's terms of reference: main focus is on the 4 sectors (agriculture, energy, industry, domestic use) because of their being consumptive, but this framework can be expanded to include non-consumptive uses.

Martina Flörke mentions the possibility of using water availability in a river basin as an approach that can address navigation aspects.

Cornelius Laaser (Ecologic Berlin) highlights the fact that regarding the project's inventory of measures, this inventory is conceived as an open structure, measures related to navigation can be taken up.

Philippe Quevauvillier (DG Research) misses link with other research projects occurring at the moment, e.g. Circe, based in the Mediterranean region. He sees the need for a link or at least commenting from these projects.

Ernst Überreiter (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management) misses the water management sector among the sectors addressed by the study.

Cornelius Laaser suggests the sector is included, although not strongly emphasised in presentation, and asks which particular focus was he referring to?

Ernst Überreiter misses water quality, and water supply and sanitation.

Martina Flörke answers that water quality is still a difficult issue with regards to modeling; however, work is being done on the topic and to the end of the year some results will be provided. Problem with nutrients, say.

Sergey Moroz (WWF) highlights the fact that there is no focus on the environment. The sectoral approach is probably easier and as such understandable, but he misses the consideration of environmental aspects such as ecosystem resilience.

Martina Flörke confirms that there is no consideration of the environment as a consumptive sector.

Natasha Marinova (Alterra) mentions that there is some implicit consideration of the environment in the project's Vulnerability Indicators. One can set minimum flows to environmental flows, for instance.

Thomas Stratenwerth (German Federal Ministry for Envirronment, Nature Conservation and Nuclear Safety) asks how the project's approach regarding adaptation and vulnerability fit into the overall strategy of the European Commission.

Jacques Delsalle replies that the project's ToR were written straight after the White Paper on Adaptation; the project is in line with this. There have been posterior changes. This project will develop the state of the art in the subject.

Rob Swart (Alterra) comments that risk is usually considered with regards to probability, and there is currently no possibility of assigning probabilities to scenarios.

Natasha Marinova highlights the fact that there is some risk incorporated into the Vulnerability Indicators.

Pierre Strosser (ACTeon) introduces the project Explore 2070, from the French Ministry of Ecology, scoping long-term adaptation needs. He is interested in comparing approaches and see if results can be combined. He asks how several issues are addressed within the project's IAF:

1) Biodiversity.

2) Water storage: reservoirs and reservoir management.

3) How to deal with temperature.

4) As he understands it the project does not work using probabilities. But how do you work if you do not at some moment use probabilities?

Rob Swart replies in regard to 4) that the results of projects do not give probability of scenarios, but work on flooding and other subjects does.

Martina Flörke replies in regard to 3) that JRC has performed lots of modeling, and is involved in the projects Scenes and Ensembles. Consortium has used what JRC has. Regarding 1), environmental flow issues are being addressed by a Swiss expert at JRC. Approach has never been used at this scale (EU-27). If an adaptation measure is implemented it cannot be evaluated at the European scale within this project. Regarding 2), these issues can be related to river discharge, e.g. hydropower. Regarding 3), some work is currently taking place by people from Deltares within these projects.

Jacques Delsalle says that Luc Feyen, attending later, is working on an approach in which Lisflood results are mapped over the location of power plants.

A stakeholder comments that the approach is indeed there; the problem is that the input of temperature level is missing. He knows of studies showing that efficiency of cooling of e.g. nuclear power plant is strongly reduced with a small increase of temperature in river water.

Martina Flörke adds that there are some models using air temperature and linking it with water temperature. In the future these kind of links will be possible within the IAF. Regarding reservoirs, WaterGAP already covers some issues. There are some generic rules included: sometimes they work, sometimes they don't. Issues such as water transfers between different reservoirs or basins for instance cannot be modeled. Data availability has been increasing over the last years.

Sonja Koeppel (UNECE Water Convention), in view of UNECE Water's work on transboundary issues, mainly in Eastern Europe, Caucasus, and to a lesser extent in South Eastern Europe, asks if these countries are being analysed, and if transboundary issues are being considered.

Martina Flörke answers that grid scale manages input for the parameters of e.g. sectors, sometimes data is taken for country and downscaled to grid-scale as average for country.

Sergey Moroz, wants to bring the discussion back to the subject of risk. He sees top-down approaches as valuable; bottom-up approach seems to be incorporating risk. He sees value in combining both in an analysis.

Natasha Marinova highlights that the project is not a research project, but only collates existing information.

Jens Goetzinger (Saarland Ministry for Environment, Energy and Transport) asks who the end-user of the software that is being generated in the project will be.

Jacques Delsalle answers that the concept is that the IAF is accessible through the Clearing House and WISE, so that it can be used for the next generation of RBMPs. He emphasises that DG Environment does not want to develop a system that will only be used by DG Environment.

Martina Flörke adds that the project is a living database.

Pierre Strosser asks what are the mechanisms that the project will use to make sure that requirements of stakeholders at the local level are incorporated into this tool. These might be very different to those at EU level.

Martina Flörke says that this is one of the reasons for the workshop, and this should be one of the outcomes today.

Geoff Darch (Atkins) highlights the issue of scale: broad-scale input and broad-scale models give broad-scale outputs. He strongly supports a vulnerability-based approach and not an approach based on risk.

Thomas Stratenwerth asks if the approach will be able to tell which regions' measures will be most helpful in increasing resilience, e.g. something along the lines of a regional sensitivity of the adaptation measures.

Martina Flörke comments that economic consequences are analysed within the model. Countries can be compared regarding GDP developments. Implementation of measures also related to question of money available. Model used addresses issue of monetary resources.

2nd session: Integrated Assessment Framework (IAF)

Project officer **Jacques Delsalle** suggests that meeting should inter alia have as result a list with rank of suggestions for the project. He highlights budget and time limitations in project. Suggestions should say what should be done and also how it should be done, data sources, etc.

Carlo Giupponi (CMCC) holds the presentation on the Integrated Assessment Framework, and asks for questions and comments.

Philippe Quevauvillier (DG Research) says that the rapid introduction to the complex subject is challenging, and project is still too theoretical for him. He highlights the need to establish close links with water-related projects, Scenes and Ensemble projects would not be specifically focused on water. There would be a possibility with Circe to test results, with much data from the Mediterranean region; these would become available at the end of the year. He mentions that he can only see a focus on water scarcity, but not on droughts.

Martina Flörke answers that the Scenes project is water-related, scenarios developed focusing on water. Scenes selected because it covers all Europe. Droughts are included within this project's IAF, this aspect is still being developed.

Carlo Giupponi highlights that one of the challenges is to provide results that don't die with the end of the project. Converting information and inputting it into a project is trivial, what has to be done is to convert it into a matrix. Substituting data-sets for others is possible. The problem resides in providing qualitative input that combines with quantitative analysis, that includes experts opinions, and that does this transparently.

Jan Brooke asks how the tool will provide answers that are cross-sectoral. Example from England: local water storage for flooding in wetland creation. Analysing it from a sectoral perspective would disqualify wetland creation due to costs, but analyzing it from a perspective that covers various sectors it proves to be a win-win solution.

Natasha Marinova replies that from the vulnerability analysis perspective, the analysis itself is integrated, showing the sectors that are vulnerable.

Rob Swart answers that whereas this is true for the vulnerability perspective, with regards to the whole IAF, these aspects can be incorporated in the side-effects. The question is also related to that of costs. No answer has been provided by the consortium on this issue yet.

Carlo Giupponi mentions the possibility of including these different sectors as criteria, and the individual levels as sub-criteria. What's important is to see if the tool, the support of decision-making, works. The possibility of users not using the data, but using the system and feeding it with their own data, is also there.

Jan Brooke sees side-effects as usually negative, also as a kind of afterthought. Term doesn't give any suggestion of the possibilities included them.

Cornelius Laaser replies that in the project's inventory of measures side-effects have been taken up, and include both positive and negative side-effects.

Rob Swart mentions that they ran into the same problem in the IPCC; the decision was made to replace "side-effects" with "co-benefits". A semantic solution, but maybe of help.

3rd session: Scenarios

Martina Flörke (CESR) holds presentation on the scenarios being used as part of the project.

Regarding the uncertainty related to models, showing increase of 100-year return level for Spain in one model, and decrease in another model: this is the kind of uncertainty that adaptation measures have to deal with. A stakeholder points out that uncertainty is magnified in a 100-year return event, less magnified in a 20-year return event.

Martina Flörke says that there is currently work being done on the subject, for instance for the Rhine, at the German Federal Institute of Hydrology, and asks Peter Krahe to share their experience.

Peter Krahe (German Federal Institute of Hydrology) says that his Institute works with ensembles of models: of around 20 models, 3 were rejected, and work is performed with the remaining 17. The approach shows bandwidth of results; these are used as scenarios (providing upper and lower limits), and then adaptation options are evaluated. This work has been performed in the Rhine basin; results should be available in ca. 1 month.

Pierre Strosser asks how uncertainty is dealt with in the case of socio-economic scenarios.

Martina Flörke answers that reality will be somewhere in between the different scenarios. Scenarios as end-results. One of the main drivers is added value. Economy First, and to some extent Fortress Europe, are used as reference scenarios, and improvements are measured against the other ones. In this way the effects of adaptation are measured. Pragmatic approach, but in this way you lose the uncertainty of the reference scenario.

Rob Swart suggests that this is a point where stakeholders should be consulted.

Halldor Bjornsson (Icelandic Meteorological Office) misses sea-level rise in the scenarios. Sea-level rise also influences issues such as pollutant flush-out. Users are more interested in having maps showing them the sea-level rise. Is there anything like this being done?

Martina Flörke replies that JRC's Luc Feyen would know if there is work addressing sea-level rise currently; he is expected later on during the day.

Natasha Marinova affirms that at the moment no European-wide maps of sea-level rise are available.

Martina Flörke summarises the use of scenarios in the project: "Economy First" and "Fortress Europe" are pretty close to being used as reference scenarios. Some elements of the other scenarios (e.g. population development) cannot be seen as developments due to adaptation to CC. But the scenarios give an estimation of the water gap that arises, and the possibility that technology or policy options have to reduce this gap. No future scenario provides a rosy future: water is also scarce in "Sustainability Eventually".

Rob Swart adds that hydrological models are based on the climate scenario A1b, and the same happens with the reference scenario "Economy First". There is consistency here, but the approach should be highlighted: it is also being used for pragmatic reasons. One of the reasons is the use of available data.

Pierre Strosser asks if uncertainty is not lost using this approach.

Martina Flörke replies that this is not really the case, because there are also 2 scenarios used as reference.

Rob Swart adds that this is a bad-case scenario: using relatively high CC levels (A1b) and bad effects regarding economic development.

Thomas Stratenwerth highlights the dangers of overestimating the economic improvements related to adaptation, when comparing with this "bad-case" future. Some elements of e.g. "Policy Rules" could be part of the future development of Europe.

Rob Swart says that the approach is consistent with the White Paper and other European projects, e.g. Peseta.

Thomas Stratenwerth agrees, but replies that this is mostly valid for climate scenarios, not for the development of water use for instance.

Jacques Delsalle highlights at this point that it is fundamental to understand the drivers.

In a final feedback round, project officer **Jacques Delsalle** underlines the importance of building something that is useful. He will draft 1-page summary of main benefits of project, user needs, and priorities. Problem of the dichotomy between water policy needs of European Commission and day-to-day adaptation, particularly regarding next generation of RBMPs. Summary will be circulated to all CIS group members, comments from them will be welcome and incorporated.

Monday, October 4, 2:30 pm.

4th session: Vulnerability Assessment

Natasha Marinova (Alterra) holds a presentation on vulnerability assessment and vulnerability indicators within the project. Three breakout groups work on the answers to 3 questions:

Q1: Do you agree with the current selection of indicators, as it is determined mainly by availability of data and scope of models (refer to background documents for further details)? If not, how can they be improved and which data sources would be used?

Q2: Adaptive capacity: What is the current adaptive capacity of your country according to the presented vulnerability indicators (Water Stress)? Does it represent current AC sufficiently? Do you have other suggestions?

Q3: How do you see the relationship between generic EU-wide indicators and location-specific characteristics of vulnerability indicators, e.g. thresholds for impacts?

Tuesday, October 5, 9:00 am.

The rapporteurs provided the following summaries of the break-out groups:

Group 1:

Q1: Vulnerability Indicators

Can we integrate the ecosystem better?

- Combine flow indicators with thresholds

How to include human influences on the natural system (reservoirs, return-flow)?

- Include as indicators? Or rather in vulnerability assessment / inventory of measures?

Specific comments:

- Aggregated indicators would be useful
- On indicators (eg. Natural ground water recharge instead long-term changes in levels)
- Take work of CIS-group on indicators into account

Q2: Adaptive Capacity

What can we use as indicators for AC?

- Implemented/planed measures difficult → neglect political dimension
- Suggestions: N° of staff working on Adaptation; Existence of administrative units

At which level should AC be measured?

- RB level would be desirable (Do regional administrative units suffice?)

Q3: Thresholds

How can we integrate regional thresholds?

- No EU thresholds possible / useful
- Maybe use sector-specific thresholds
- Design the structure for the possibility to include regional thresholds

Group 2:

Q1: Vulnerability Indicators

- No relationships yet with the proposed WFD and Flood Directive lists/definitions of indicators.
    - FloodD: preliminary assessment of flood risk; CIS working group is already working on this issue (*reference indicators and definitions*);
    - WFD: indicators on the status of water bodies (RBMP downloadable from WISE);
    - More information is required about what is going on in the policy discussion and implementation.
- Problems other than Water Scarcity, Floods and Droughts - e.g. SLR and Water Quality?
    - Scope and focus driven by *availability of data* at the EU27 level.
- The four sectors are not comprehensive enough.
    - Hydropower issue: e.g., there are data sets for the nordic regions suitable for modelling (Climate and Energy and C & E systems projects): dam regulation, safety are main issues;
- The set of indicators may be revisited to take into account a better match with actual problems:
    - Every sector has its own consolidated set of rules, methods, indicators;
    - E.g., the number of dry days in rivers: an effective ecological indicator;
    - Soil moisture is proposed, but no data available;
    - Floods are of different kinds, e.g. abrupt events of snow melting without any precipitation.
- Scale tensions (EU-local, general and specific water problems)
    - *Unequal availability* of data across the EU; difficulties in providing indicators that are useful for the whole EU;
    - However, indicators should ideally be *comparable*;
    - Explore feasibility of a system of *sub-indicators* within the proposed categories more tuned to specific policy needs.
- EEA/IPCC Exp/Sens/AC framework not the only or best one?
    - Exposure (here simplified to biophysical) and sensitivity (socio-economics) have not completely satisfactory definitions;
    - Sensitivity: change in demand or better productivity per sector (include economic dimension)?
    - Do we really want to stay within the framework or rather forget about these terms and focus on relevant indicators for impacts and measures?
- Indicators definitions to be clarified and/or improved
    - Need to be *clearer about terms*: e.g. how long is "long term";
    - Minimum river flow; Q95; minimum river discharge vs. deficit volumes as drought indicator (with specific thresholds);
    - Forget about mean values: focus on PDFs: extremes, thresholds (case specific) and risk analysis, to the extent data allow (check STARDEX, MICE?)

Q2: Adaptive Capacity

- The proposal to link (implicit) "adaptive capacity" to the "potential impacts" in the current situation (2005) seems to be attractive
    - Can we *avoid using the term AC* in our framework? What we are interested in is measures and Impacts.

- The AC could be higher than reflected by the current potential impacts, e.g. if existing *flexibility is not fully exploited*, e.g. excess storage capacity, in case not included in analysis?
- The (dynamic) difference between day to day supply and demand can be used as a proxy to determine adaptive capacity – the larger the difference, the lower the AC?

- However, the EEA/IPCC definition should not immediately be thrown over board
  - Budget, unemployment, etc. indicators (e.g. good or bad, for municipalities in Norway, region in UK) can provide indicators to support assessment of regional AC -> what are the possibilities for *scaling up to the EU*?
  - Examples are available, but not often they are successful.

Q3: Thresholds

- **Thresholds: It may be possible to determine regionally specific thresholds for some problems:**
  - Mean river flow and other general indicators are not good indicators for Europe; they need to be ***relative to something***, e.g. “normalisation” could be based upon local thresholds (e.g. its ratio with ***minimum ecological flows***, case specific available for the RBMPs);
  - Thresholds should be defined ***locally/regionally*** on the basis of technical but also economic, social, and other criteria;
  - Thresholds are used to ***identify red lights*** to warn about the need to implement adaptation measures and thus to choose among sets of possible options;
  - ***Users*** should be allowed to define their own thresholds.

Group 3:

Q1: Vulnerability Indicators

- Indicators should be harmonised in some way with
  - current EEA efforts, which also feed into the Clearing House.
  - Floods Directive
  - WFD needs (to be specified) - linking the vulnerabilities with the pressure assessment of the RBMP. Particularly those RBDs without too much resources for pressure assessment could profit from VIs that link with this part of the planning process in RBDs.
- Ecosystem-related indicators are missing. The whole subject of ecosystems and water quality is not represented well-enough in project.
- Possibility of reflecting regulatory blocks to developments, e.g. different regulations re. groundwater recharge, are missing.
- Indicators should link with definitions of Water Scarcity and those of Droughts being developed in the Working Group.
- Focus on indicators for water balance. It might be interesting to have a questionnaire to MS to see what indicators they use for the purpose of their water management.
- More concrete: sea-level rise and wind direction.
- Problem of indicator for water quality problems due to CC. Water temperature the only clear one. Possible proxy used in the UK: analyse changes to river discharge due to CC under similar conditions. Used in the first cycle of the RBMPs.

Q2: Adaptive Capacity

- Indicators for Adaptive Capacity?
- Hard ones are easier to achieve: GDP, etc.
- „Cultural“ ones are harder to measure. Issue of political sensitivity.
- Number of infringement procedures re. European legislation? (In other areas as well, not only water. Problem of past compliance not guaranteeing the future, but still valuable.)
- Which countries have Adaptation Strategies and Programmes, which ones of them have legal status? (Problem of some countries not having AS, but having regional ones, and often better than national ones).
- Possibility of linking indicators for AC with exposure Ind.
- Re. Knowledge, question of dynamism of water sector, etc. Problem of finding indicator. Possibly research in sector, proportion of state funding addressing CC, budget lines for adaptation, awareness of population.
- Problem of measuring AC at state level, but having the rest of the information, or much of it, for sector level.
- Another indicator: Existence of a Clearing house at national level, e.g. Germany, Denmark, UK.
- Transboundary agreements should be taken up in the evaluation of adaptive capacity.
- Question is posed if we are trying to measure issues related to government, etc., or are we trying to measure the reduction of impacts of CC.
- Existence of urban planning.
- Future-proofing of infrastructure.
- Possibility of using 3-tier guidance on adaptive capacity: awareness, existence of planning (e.g. urban planning), actual implementation of adaptation.

Q3: Thresholds

- How to work with the different ranges? Some indicators seem to need site-specific indicator thresholds, others don‘t, e.g. water balance.
- Suggestion is that users should define this.
- Strong dependency on infrastructure available.
- In the case of droughts, thresholds are easy to collect, because there is a moment in which emergency plans kick in. More difficult in the case of flooding and water scarcity.
- Indicators differ according to sectors. E.g. navigation has problems with flooding when the water is still channeled, e.g. when floods haven‘t occured for other sectors. Same with low flow. Indicator can be common, but having different thresholds.
- (Much of this information will be available by Dec 2011.)

Tuesday, October 5, 10:30 am

5th session: Inventory of measurs

Thomas Dworak (Ecologic Vienna) holds a presentation on the inventory of measures. He opens the floor to comments and questions from the stakeholders.

Round of comments:

1) Structure of the inventory

- Q: Are information from industry and other sectors being taken into account? → A: Only to the extent that information has been available publicly (reports, national information platforms, etc).
- Q: Can examples be somehow made available?
- Time horizon of measures needs to be clarified. What does it refer to: lead-in time? Time to implementation? → A: Time refers to financial horizon. The need to clarify this point is acknowledged.
- What is the level of measures? E.g. certain measures are grouped e.g. relating to modifying infrastructure.
- How can regional differences in acceptance be addressed?
- Q: Is it useful at all to provide information on cost at a European level? Maybe better to use national / regional information? → A: Maybe use qualitative evaluation (low to high) as default, but can be exchanged with concrete regional values in the DSS for the assessment
- Do measures relate to the PoM? Difficulty may be that measures are taken to address existing pressures and then may be adapted to cope with climate change.
- **Jacques Delsalle**: Inventory should be linked closer to other existing inventories, e.g. Floods Group worki on flooding measures, work happening in future re. Natural Water Retention Measures, JRC efforts → the structure should be flexible enough to incorporate this information.

2) Assessment of attributes

- Q: **Thomas Dworak** asks the stakeholders how they would deal with the assessment questions. → A: Focus on quantification seen as of secondary importance, approach should immediately qualify on a relative scale the measures. This relative scale could be linked to context. E.g. Environment Agency in England classifies the cost of measures according to the organizational response required, e.g. Level 1: Have to go to government for additional funding, Level 2: Major re-shuffle of funds necessary, … Level 4: Low cost.
- This approach is supported by the opinion that qualitative assessment is considered best practice for multi-criteria analysis.
- Objection is made that Database should be able to hold both types of evaluations, qualitative and quantitative.
- **Jacques Delsalle**: link to examples is important
- **Carlo Giupponi**: the proposed criteria can be used also for a mixed approach (quantitative & qualitative assessment)
- **Jan Brooke**: why are the measures actually really assessed (going beyond building the structure of assessment)
- **Jacques Delsalle**: assessment was initially thought to inform the EC about usefulness / effectiveness of measures to be recommended for the further development of EU strategy. Also guide the design / recommendation for including measures in the 2nd cycle of RBMPs
- **Jacques Delsalle**: 13 measures are indicated as being able to be modeled – that shouldn't be too much
- **Jacques Delsalle**: the inventory of measure serves mainly as knowledge base
- **Jacques Delsalle**: short-listing the measures to be modeled will be discussed further in the Consortium
- The preliminary assessment of measures will be discussed at the second stakeholder workshop

- **Thomas Stratenwerth**: one component is the inventory, users then can select a subset of measures to evaluate with multi-criteria assessment tools, BUT the wish of the EC to evaluate a set of measures with models to steer European Policy is a second and separate purpose
- **Thomas Stratenwerth**: if the DSS provides the possibility to select subset of measures
- **Thomas Dworak**: a tool might be needed providing an interface between the inventory of measures
- **Rob Swart**: Clear now on how to use the inventory & the DSS for regional decision making, but how measures can be modeled and how results can be included in the IAF (and for what purpose) still needs clarification
- **Martina Flörke**: some measures can be modeled (additional storage capacity)
- **Thomas Stratenwerth**: for short-listing maybe a criterium could be to think about who should be addressed by the results: regional decision makers vs. EC need for information to support policy decision making.

Rounding up of workshop - Next steps:

Models: Data is becoming available: SCENES, river basins, water use modeling. Different drivers are being compiled.

Vulnerability Indicators: revision of indicators proposed in the workshop. **Natasha Marinova** estimates that draft sets of indicators will be ready within 2 weeks, and asks for feedback before then.

Inventory of measures: Include returns from questionnaire, include expert evaluation (requirement from UK to see how they use their qualitative criteria), improve interface with DSS, look into measures that will be modeled, and their limitations.

Tuesday, October 5, 12:00 am: End of workshop.

Annex A: List of participants

N°	LAST NAME	First name	Organisation	Country
1	**Arama**	Guillaume	EUREAU	France
2	**Aschwanden**	Hugo	Bundesamt für Umwelt	Switzerland
3	**Bjornsson**	Halldor	Icelandic Met. Office	Iceland
4	**Bonaiti**	Gabriele	Euro-Mediterranean Irrigators Community (E.I.C.)	Spain
5	**Boveda**	Myriam	Energies Demain	France
6	**Brion**	Carla	Flemish Environment Agency	Belgium
7	**Brooke**	Jan	PIANC and ESPO	UK
8	**Darch**	Geoff	ATKINS	UK
9	**de Lacaze**	Xavier	French Ministry of Ecology	France
10	**Delsalle**	Jacques	European Commission	
11	**Dworak**	Thomas	Ecologic Intitute Vienna	Austria
12	**Fardon**	Lynn	Defra	England
13	**Feyen**	Luc	European Commission - JRC	
14	**Flörke**	Martina	Uni Kassel, CESR	Gemany
15	**Gibek**	Jakub	National Water Management Authority	Poland
16	**Giupponi**	Carlo	CMCC	Italy
17	**Goetzinger**	Jens	Saarland Ministry for Environment, Energy and Transport (& LAWA)	Germany
18	**Hilbert-Bastian**	Christine	Administration de la Gestion de l'Eau	Luxembourg
19	**Horvath**	Balazs	European Commission	
20	**Koeppel**	Sonja	UNECE Water Convention	Switzerland
21	**Krahe**	Peter	Federal Institute of Hydrology	Germany
22	**Kroc**	Artur	National Water Management Authority	Poland
23	**Laaser**	Cornelius	Ecologic Institute Berlin	Gemany
24	**Lavray**	Hélène	EURELECTRIC	Belgium
25	**Marinova**	Natasha	Alterra	Netherlands
26	**Matauschek**	Michaela	Ecologic Intitute Vienna	Austria
27	**Mol**	Sandra	Dutch Ministry of Transport, Public Works and Water Management	The Netherlands
28	**Moroz**	Sergey	WWF European Policy Office	Belgium
29	**Mrkvičková**	Magdalena	T.G. Masaryk Water Research Institution, p.r.i.	Czech Republic
30	**Nam**	Andrea	European Commission	
31	**Nedvědová**	Emílie	Ministry of Environment of the Czech Republic	Czech Republic
32	**Nyroos**	Hannele	Ministry of Envirmonment	Finland
33	**Pedusaar**	Tiia	Ministry of the Environment	Estonia
34	**Quevauviller**	Philippe	DG Research (Climate Change and Environmental Risks)	Belgium
35	**Raasakka**	Nina	European Commission	
36	**Rodríguez Montañés**	Lucía	Ministry for the Environment	Spain
37	**Romanowicz**	Agnieszka	European Commission	

38	**Solvoll**	Kjersti	Directorate for nature management	Norway
39	**Stratenwerth**	Thomas	Federal Ministry for Envirronment, Nature Conservation and Nuclear Safety	Germany
40	**Strosser**	Pierre	ACTeon	France
41	**Swart**	Rob	Alterra	The Netherlands
42	**Tomescu**	Mihai	European Commisission	
43	**Ueberreiter**	Ernst	Federal Ministry of Agriculture, Forestry, Environment and Water Management	Austria
44	**Ureta Maeso**	Jorge	Ministry for the Environment	Spain
45	**Vakrou**	Alexandra	European Commission	
46	**Valente**	Marta	Ministry of Environment	Italy
47	**Van Steerteghem**	Marleen	Flemish Environment Agency	Belgium
48	**Veiga da Cunha**	Luis	National Water Institute	Portugal
49	**Vidaurre**	Rodrigo	Ecologic Institute Berlin	Germany
50	**Wimmer**	Florian	Uni Kassel, CESR	Germany
51	**Wright**	Julian	Environment Agency	England and Wales

1.2 Minutes of 2nd stakeholder workshop

Center for Environmental Systems Research

European Commission

Directorate-General Environment

Workshop Report - Summary

Climate Adaptation – Modelling Water Scenarios and Sectoral Impacts (ClimWatAdapt)

2nd Stakeholder Workshop

Wednesday, March 30th – Thursday, March 31st 2011, Ministry of Rural Development, Budapest, Hungary

The project is lead by CESR – Center for Environmental Systems Research

In co-operation with

ecologic ALTERRA Centro Euro-Mediterraneo per i Cambiamenti Climatici