Water2Adapt

Resilience enhancement and water demand management for climate change adaptation

Water2Adapt Project

Synthesis report

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Water2Adapt: Resilience enhancement and water demand management for Climate Change Adaptation

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Executive summary

Water scarcity and drought in Europe

The Water2Adapt project started from the recognition that the far-reaching economic, social and environmental impacts of droughts and water scarcity are not known in sufficient detail. Moreover, the European Commission's Communication of Water Scarcity and Drought (EC, 2007) provided unclear boundaries between water scarcity and drought, mixing trends, risk and variability. As evidenced by the Commission's Review of the Policy on Water Scarcity and Droughts (COM(2012)672), small progress have been made in the implementation of the seven policy options of the 2007 Communication (i.e. right water price, efficient water and funding allocation, improved risk management, additional water supply infrastructures, efficient technologies, water-saving culture, improved knowledge and data collection). The recent Blueprint for Safeguard Europe's Water resources (COM(2012)673) has laid out new roadmap for an improved water and drought risk management in Europe.

Motivation of the project

The Water2Adapt project, as a small-scale European applied-research project, aimed at producing policy-relevant knowledge and recommendations for water demand management at River Basin District's (RDB) scale for the appropriate implementation of the EU Water Framework Directive (WFD).

Methodology

The Water2Adapt project has analysed drought events in three representative river basins in Spain (Ebro), Italy (Po) and Germany (Weser). All three river basins had been evidenced as being water stressed (EEA, 2005), despite the arguably abundant annual water resources available. The analysis focussed on the economic losses, social hardship and rural/urban resilience to water scarcity and drought.

In Spain, the case sites included the rural district Álava of the Basque Autonomous Country (BAC) and its capital city Vitoria (in Basque Gasteiz). In Italy, the rural case site was confined by the district Piacenza situated in the Region Emilia Romagna (RER), and the basin of the Trebbia river – a right tributary of Po river. Parma and Ferrara - capitals of the homonymous districts of the RER – were chosen as urban case sites for their specific exposure and vulnerability to droughts. In Germany, the Heidekreis and the Lower Saxony's capital town Hannover were chosen as rural and urban site respectively. The analysis on the Ebro RB case study focussed on the 1988-1990 drought, one of the three most significant drought spells in BAC since 1944. The Po RBD, normally water rich, experienced severe droughts throughout the 2000s, in particular in 2003 and 2006-2007. The Weser RBD analysed the 2003 event, one of the worst drought spells on record.

Key results

The Water2Adapt Project provided policy recommendations for each analysed RBD. From among the policy areas identified in the 2007 Communication, the results indicated that: putting the right price on water is a priority of Southern Europe case studies; the introduction of volumetric water prices in Italy and Spain for the agriculture sector could reduce potential water stress during scarce periods; the improvement in water supply infrastructure is a policy recommendation considered by both the German and Spanish case studies; improving the governance at RBD level is an essential requirement in the Italian case study; fostering water efficiency technologies and practices could be achieved through water saving in buildings (Italy), waste water reuse and rainwater retention (Germany), reduced water leakage in both civil supply and agriculture (Italy and Spain); innovative economic-policy instruments such as water transfer and water markets are considered as potential solutions against increased water competition between sectors such as energy and agriculture; and finally, all case studies have identified the necessity to include climate change scenarios in the development of water management plans for appropriate inter-sector water allocation. In addition, the Italian case study has contributed consistently to the National Climate Change Adaptation Strategy (Special Chapter on the Po RBD).

Concluding, this report is an additional effort towards the European debate about water scarcity and drought, which defines concrete actions at RDBs' scale. Amongst other issues the Project addressed the following gaps: it delved into nuances of drought drivers and impacts; it characterised drought events; it evaluated droughts impacts and losses both economic and social; it provided ex-ante assessment of measures in place, institutional responses and governance; and finally it provided RBDs' specific recommendations for water scarcity and drought risk mitigation and climate change adaptation enhancement.

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1 Introduction

Water scarcity and drought in the European Union

Droughts are natural, recurrent phenomena, triggered by deficient precipitation and manifested through reduced soil moisture, run-off, aquifer and reservoir recharge, and river stages. The impacts of drought are exacerbated by inefficient water allocation/or and management practice. *Water scarcity* is man-made, recurrent imbalance caused by consumption exceeding the natural renewable water availability and aggravated by water pollution (see also Schmidt et al, 2012).

The European Water Framework Directive (WFD, Directive 2000/60/EC), 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 issues of water scarcity and droughts have been further addressed in the Communication of the European Commission (COM (2007) 414 final) and, more recently, in the Blueprint for Safeguard Europe's Water resources (COM (2012) 673). Efficient water use is also a cornerstone of the EU Resource Efficiency Flagship initiative as a part of the Europe 2020 Strategy. Improved efficiency of water allocation and use, coherent application of water pricing and cost recovery principle, and better planning for drought spells, likely to be amplified by climate change throughout Europe are widely accepted as the most effective ways of adapting to climate variability and change.

Growing frustration with the slow and uneven rate of implementation across the Member States (MS); the Review of the River Basin Management Plans (EC, 2012) indicates that a significant number of EU water bodies 'will not reach *good status* by 2015 due to both long-standing and emerging challenges'. Water scarcity and droughts under current or future climate have been identified as an important threat in some RBDs. European parliament (EP) called several times upon the Commission to submit legislation, 'similar to the directive on floods, which encourages the adoption of an EU policy on water shortages, droughts and adapting to climate change'.

Objectives of the project

The Water2Adapt project was born from the recognition that the wide-reaching effects of droughts, and water scarcity, on regional economies and social wellbeing are not known in sufficient detail (Mysiak et al, 2011). The inattention to causes and impacts of water stress precludes water reform and efficient water re-allocation. As an applied-research project, the Water2Adapt project sought to produce policy-relevant knowledge and recommendations for water management and the implementation of the WFD. Over a period of two years (September 2010 – October 2012), the project teams analysed the economic and social costs and hardship inflicted by drought, and water scarcity in general, in rural and urban contexts, and reviewed the risk mitigation measures and policies suitable to reduce water stress and induce more efficient use of water resources.

Case river basins, reference areas and revisited drought events

The analysis focused on *three representative river basin districts* (RBD) in Europe: Ebro (Spain, limited to Basque Country), Po (Italy) and Weser (Germany) (see Figure 1). Taken together, the area comprised by the three RBD equals to around a fourth of the Danube river basin, the second largest river basin in Europe and the largest in the European Union. Ebro and Weser RBDs were among the Pilot River Basins (2002-04, 2005-06) of the Common Implementation strategy (CIS), whereas Po RBD is among the pilot cases of the European Expert Group on Water Scarcity and Drought.

Case river basins

Ebro is the longest (~910 km) and the largest (by discharge) river in Spain; and the longest and second largest (by basin area ~85.6 thousands sq.km, after Rhône) from among the European rivers draining into the Mediterranean (Balearic) Sea. Only a small part of the RBD is situated in France and Andorra. As on December 1st 2012, the River Basin District Management Plan for Ebro has not been submitted. Less than 40 per cent of the surface water bodies will reach the good ecological status by 2015 (EEA, 2012).

Figure 1: The case river basin in the context of the River Basin Districts (RBD) of the EU Water Framework Directive (WFD, Directive 2000/60/EC). Ebro and Po are among international RBDs although their trans-national importance is very limited. The upper part of Weser RBD belongs to *Central highlands*, whereas the downstream part is situated in the *Central plains* ecological regions (ERs). Ebro and Po RBDs belongs to *Ibero-Macaronesian* and *Italy/Corsica* ERs. *Data source*: EEA and Eurostat, elaboration by FEEM.

Po is the longest (~682 km) and largest (by discharge and basin ~74 thousands sq.km) river in the Italian Peninsula, and the third longest and largest European river draining into the Mediterranean (Adriatic) Sea. With a natural endowment amounting to some 78 billion m^3 annually, the basin is one of the water-richest in Italy. Around a fourth of it is withdrawn for anthropic uses, especially irrigated agriculture – the largest consumptive water use in the basin (~80 per cent of water withdrawals). Industry and civil uses are minor users but changing trends could influence their importance. Less than 40 per cent of the surface water bodies will reach the good ecological status by 2015 (EEA, 2012).

Weser is formed by the confluence of the rivers Fulda and Werra and drains into the North Sea. The join length of Weser (measured from the point of confluence) and Werra makes it second longest (752 km, after Rhine and before Elbe) and fourth largest (by basin area ~49 thousands sq.km) river in Germany. Less than 10 per cent of the surface water bodies will reach the good ecological status by 2015 (EEA, 2012).

Reference areas

Within each basin, case site areas have been chosen for analysing the drought's impact in the rural and urban contexts (see Table 1 and Figure 2). All rural case sites represent districts of the Eurostat NUTS3 level (Nomenclature of territorial units for statistics, EUROSTAT, 2013). The urban case site were chosen from among those included in the Eurostat Urban Audit (EUROSTAT, 2013).

River basin district	Length/ basin area (km/km2)	Discharge Q (m3/s)	Population ('000)	Precipitation (mm)	Drought events	Rural site (area '000 km2)	Urban site (pop '000)
Ebro	910 85.534	426	3.000	200- 2000	1988-1990	Álava district (2.97)	Vitoria-Gasteiz (235)
Po	682 71.000	1.540	17.000	400- 2000	2003, 2006-07	Trebbia (1.2) Piacenza (2.6)	Parma (187) Ferrara (135)
Weser	452 (752) 49.000	325	9.300	400- 2000	2003	Heidekreis (1.9)	Hannover (526)

Table 1: Overview of the case basins and rural/urban case sites chosen for the analysis.

In Spain, the case sites include the rural district *Álava* of the Basque Autonomous Country (BAC[1]) and its capital city *Vitoria* (in Basque *Gasteiz*). Some 318.730 inhabitants are living in Álava district, mostly concentrated in the city Vitoria. With about 105 inhabitants per square kilometre, the population density of the district is the smallest of the BAC. The district is classified as *intermediate* by EUROSTAT but counts as rural territory in the sense of the 2010 Rural Development Plan. The GDP per capita is ca. 20 per cent higher than the average in BAC (~32.229 Euro per capita). The economy of the district is driven by tertiary sector (services, ~53 per cent of the GDP) and secondary sector (production ~ 38 per cent and construction 7 per cent of the GDP). Only about 2 per cent of the macroeconomic output is produced by agriculture. The *Gross Domestic Product* (GDP) at NUTS3 regional level per capita ranges between slightly below EU27 average (Huesca) to above 130 per cent of the EU average, with the Álava district showing the highest value (137 per cent).

The main source of water supply is a surface source stored in the reservoirs of Ullibarri and Urrunaga (hereafter referred to as Zadorra system). The capacity of these reservoirs reaches 180 million m^3, of which 80 per cent are transferred to the Cantabrian river basin, and then the city of Bilbao and surroundings (Gran Bilbao). The multiple users system involves the two water utilities of Vitoria-Gasteiz and Bilbao, and an energy utility. The current water demand amounts to 91 million m^3 for the industrial sector, self-supplied by two third, 56 million m^3 for the residential sector of which 80 per cent is supplied through the transfers, and 27 million m^3 for the agricultural sector. In the Zadorra, the flow of 36.800 litres/second produces 141 GWh per year.

[1] The Basque Autonomous Country (BAC) is an autonomous community of northern Spain comprising the provinces of Álava, Vizcaya and Guipúzcoa. The Ebro RBD comprise almost the whole territory of Álava.

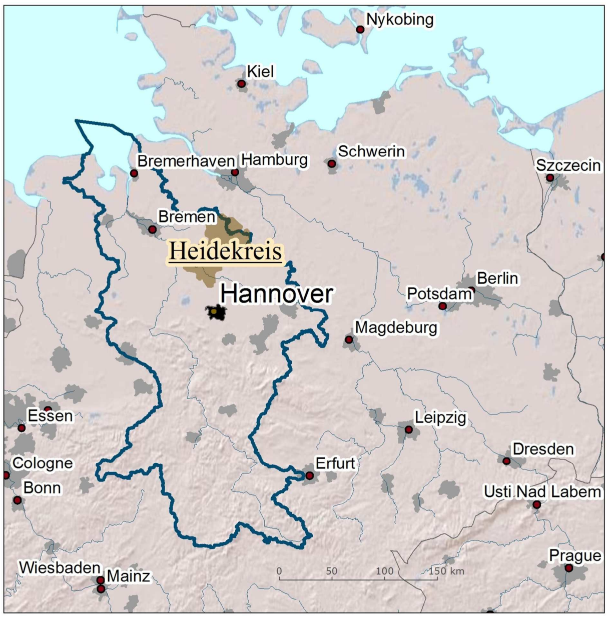
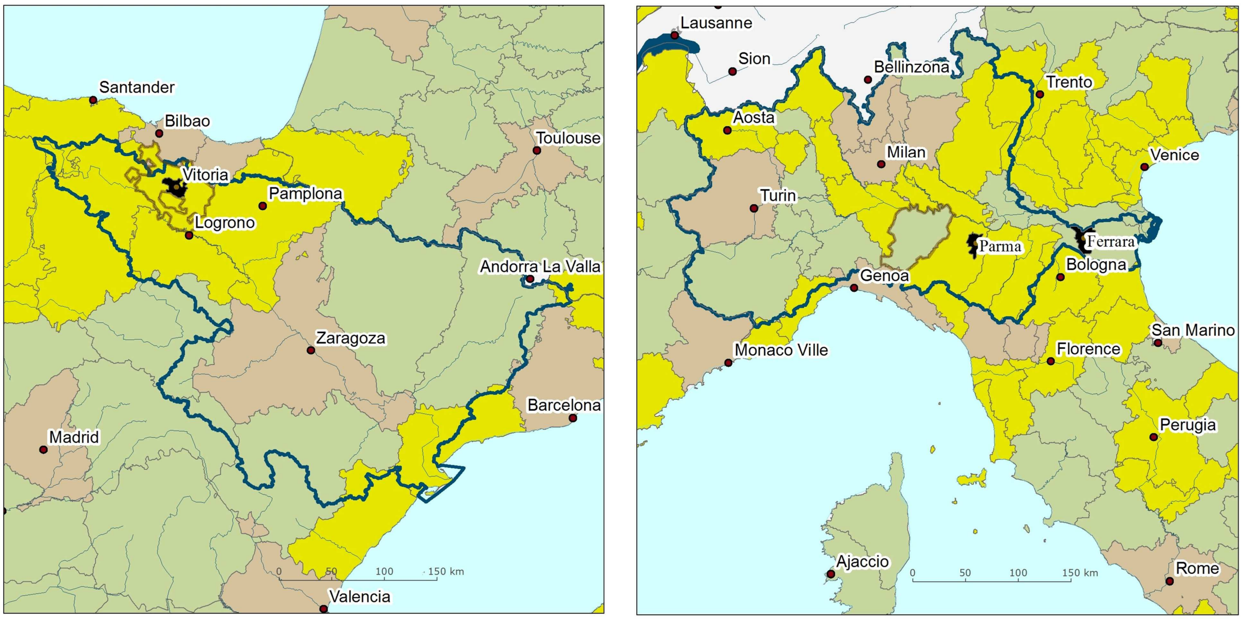


Figure 2: Case basins and sites: (*left up*) Ebro RBD: Álava, Vitoria/Gasteiz city; (*right up*) Po RBD: Piacenza-the Trebbia sub-basin, Parma and Ferrara towns; (*left down*) Weser RBD: Heidekreis district and Hannover city. Only in the Spanish case study the urban site is contained by the rural district analysed, in the German and Italian case studies the rural and urban sites are spatially detached. *Data source*: EEA and Eurostat, elaboration by FEEM.

In Italy, the rural case site in confined by the district Piacenza situated in the Region Emilia Romagna (RER), and more specifically the basin of the Trebbia river – a right tributary of Po river, known as a battleground of the Second Punic War back in 218 BC. Piacenza is one of the only two RER districts classified by EUROSTAT as predominantly rural, and the only interruption of a large metropolitan area extended from Venice (Veneto region) up to Milan (Lombardy) and then along the Emilia Road back up to Bologna (RER) (see also Figure 4). Unlike the Ebro case study, the urban case sites in the Po RBD have been chosen from outside of the rural district. Parma and Ferrara - capitals of the homonymous districts of the RER - have been chosen because of their different exposure and vulnerability to droughts. The Parma town's main source of water supply is the aquifer, a natural underground reservoir, whereas Ferrara town draws the water directly from Po river. Both Parma and Ferrara are middle-sized towns, smaller than Vitoria (BAC) but representative for the region. The GDP at NUTS3 regional level per capita ranges between slightly below EU27 average (Verbano-Cusio-Ossola district) to above 160 per cent (Milano district).



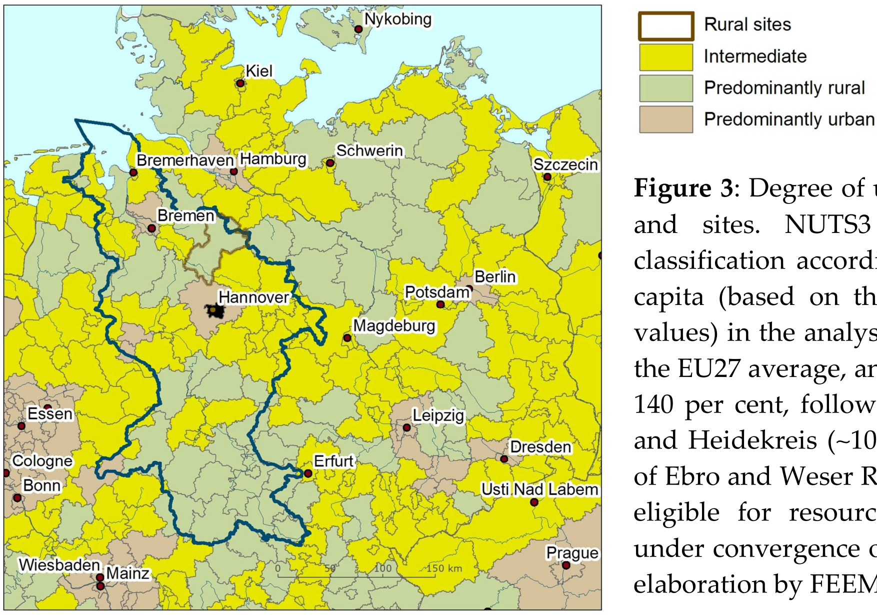
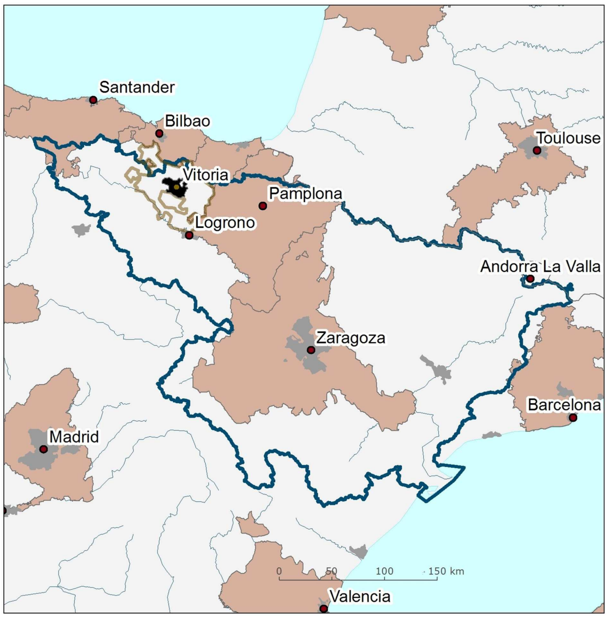
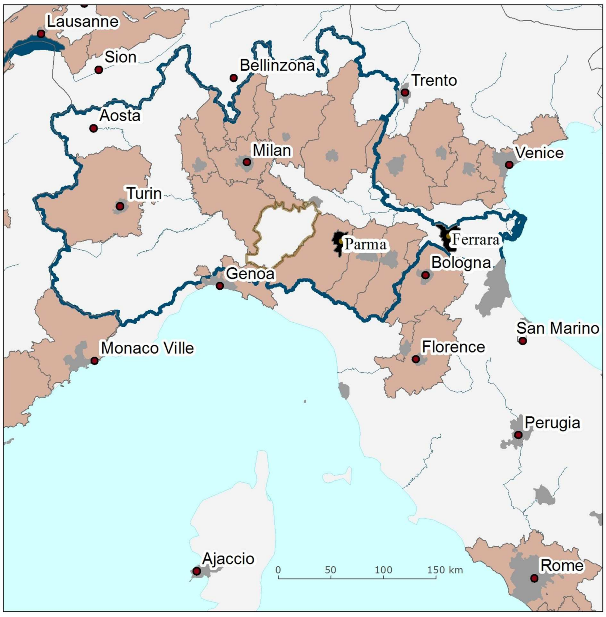


Figure 3: Degree of urbanisation of the case basins and sites. NUTS3 units (districts) and their classification according to Eurostat. The GDP per capita (based on the available values 2007-2009) values) in the analysed rural districts are all above the EU27 average, and is highest in Álava (Spain) ~ 140 per cent, followed by Piacenza (122 per cent) and Heidekreis (~107 per cent). Small proportions of Ebro and Weser RBDs fall under NUTS2 regions eligible for resources from EU Cohesion Fund under convergence objective. *Data source*: Eurostat, elaboration by FEEM.

The *Heidekreis* (until recently Soltau-Fallingbostel), the rural case site in Germany, is also classified by EUROSTAT as predominantly rural, although enclosed by a metropolitan area of Hamburg und Hannover-Braunschweig-Göttingen-Wolfsburg. It owns its name to the surrounding Lüneburg heath, a shrub land growing on acidic soils. Around half of the *Lüneburg Heath Nature Reserve* is located in the Heidekreis district. The urban case site is formed by the capital town of the federal state (Bundesland) Lower Saxony. Compared to the urban sites in Ebro and Po RBDs, Hannover is twice as large and counts as a large-sized city. The *Gross Domestic Product* (GDP) at NUTS3 regional level per capita ranges between below 70 (Gifhorn, Wolfenbuettel and Osterholz districts) to above 170 (Bremen, Kassel, Wolfsburg districts) per cent of EU27 average. The GDP per capita of the Heidekreis district is slightly higher than the EU27 average (107 per cent).





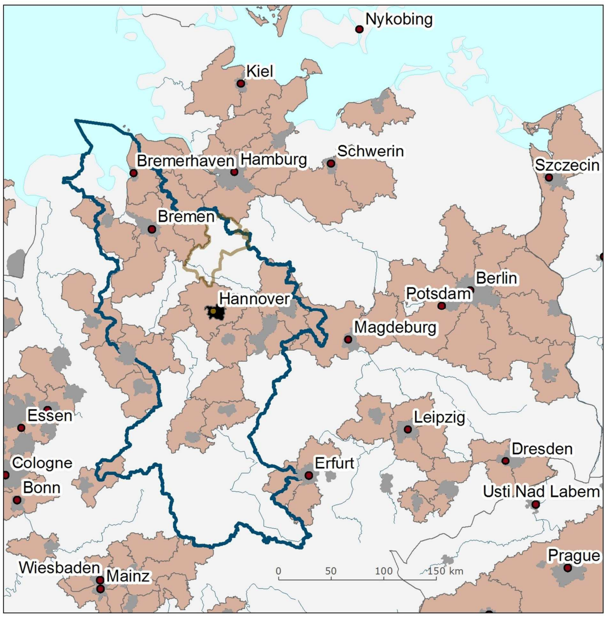


Figure 4: Degree of urbanisation of the case basins and sites. Metropolitan region according to Eurostat.

Revisited drought events

In the Ebro RBD, the analysis focussed on the 1988-1990 drought, one of the three most significant drought spells in BAC since 1944. During the drought that lasted for twenty eight months the stock of water in the Zadorra system fell from 180 million m^3 to 5 million m^3. Severe water restrictions, ranging between six and twelve hours per day, had been imposed for 10 months. The Po RBD, normally water rich, experienced severe droughts the 2000s, in particular in 2003 and 2006-2007. The government-declared state-of-emergency persisted for twenty-one months, and exceptional meteorological conditions in parts of the basin were attested for eight out of ten years, paving so the way for agricultural aid programs. The Weser RBD analysed the 2003 event, one of the worst drought spells on record.

2 Workflow, methodology and data sources

The research conducted (Figure 5) involved: 1) selection of the significant drought events in the reference river basins and critical review of the existing assessments of the drought's economic and social impacts; 2) analysis of the drought response policies (including water governance) and measures; 3) identification of the amplifying and attenuating factors of the drought impacts; and 4) assessment of the future gaps between water availability and demand, and identification of climate adaptation policies suitable to fill the gap.

<table>
<tr><th rowspan="2">Economic impacts</th><th colspan="2">Social impacts</th><th rowspan="2">Drought management</th></tr>
<tr><th>Rural environment</th><th>Urban environment</th></tr>
<tr><td colspan="4">Choice of recent significant drought spells</td></tr>
<tr><td rowspan="2">Critical review of the estimates of economic impacts</td><td colspan="2">Collecting information about the social impacts of drought, stakeholders' consultation and synthesis</td><td>Response to drought</td></tr>
<tr><td>Rural mainly agricultu-ral NUTS3 districts,</td><td>Urban centres with > 100 thousands inhabitants</td><td rowspan="2">Potential climate change adaptation measures</td></tr>
<tr><td colspan="3">Factors influencing community resilience</td></tr>
<tr><td colspan="4">Scenarios of water use and demand</td></tr>
</table>

Figure 5: Workflow of the project

Ebro case study team has drawn the analysis in the rural context on: 1) interviews with representative stakeholders institutions including the *Basque water agency* (URA), the *Community of irrigators of Llanada Alavesa* (UAGA), the *Department for the Environment of the "Diputacion Foral de Alava* (DFA)", and the *Ebro River Basin Authority* (CHE); 2) literature review and empirical analysis of data from the *Basque Government and the Basque Institute of Statistics* (EUSTAT). The urban assessment concentrated on the water demand management plans implemented of the water utility *Aguas Municipales de Vitoria SA* (AMVISA). The data used for the assessment has been obtained from: 1) interviews conducted with representatives of the *Basque Water Agency* (URA), the DFA, CHE, AMVISA, and *Consorcio de Aguas Bilbao Bizkaia* (CABB); 2) literature review and empirical data obtained from the URA, the governments of Alava, water utilities, and the EUSTAT.

The Po case study team used the data of the Italian *Farm Accountancy Data Network* (FADN) of the *National Institute for Agricultural Economy* (INEA), the *Italian Statistical Bureau* (ISTAT), and the *Electricity Transmission System Operator* (Terna S.p.A.), *Gestore dei Servizi Energetici* (GSE), the *Regional Environmental Protection Agencies*, and other sources. The Po case study team has conducted a series of interviews and workshops with the key stakeholders and undertaken a critical review of the water/drought management and conservation plans.

The Weser team collected data using a semi-open questionnaire distributed to farmers with a range of different farming systems (ranging from forage to cash crops to livestock) were interviewed. The questionnaire was based upon investigations of Walker et al. (2002) and Walker and Salt (2006) into resilience analysis, but adapted to regional circumstances and agricultural conditions. The questions referred to characterization of the farm system, experiences with climate change and droughts in particular, measures for climate change adaptations, the networks and education levels of farmers, and future development plans for the farm business. Indicators for social resilience were developed. The urban vulnerability assessment involved a detailed review of the relevant literature produced by the municipality, the regional authority, public utilities and other regional and national government agencies, as well as related scientific projects. Interviews with experts from a range of mainly regional and municipal agencies, as well as representatives of the river basin authority also provided much of the information contained in the assessment. A review workshop with main stakeholders has completed analysis.

3 Economic effects of water scarcity and droughts

3.1 Synthesis across the case studies

Unlike other meteorological and climatologic hazards, *droughts* are slow-onset (creeping) calamities with ramified, far reaching and for the most part non-structural impacts, with rippling effects on economy, society and environment. The impacts accumulate with drought conditions persisting over time, and after the drought has ended. Inefficient allocation and use of water, and other management malpractice contribute to amplify the impacts of drought.

The assessment of drought-related economic losses faces substantial conceptual and methodological challenges. The *direct* economic impacts can be measured in terms of production losses and impaired services. It is however widely acknowledged that induced and indirect (higher order) effects of drought (Rose, 2004) may outweigh the direct losses. Agriculture, hydro- and thermo-electricity generation, domestic water supply, water navigation, and water-intensive manufacturing, affected by less-than-usual water availability, are likely to curtail their activities and production, collect less revenues, lay-off staff, and postpone all but critical investments. These direct losses set off a sequence of 'up'- and 'downstream' reactions which affect their suppliers and customers.

Higher order effects can be assessed using macroeconomic models such as Input-Output (I-O) or computable general equilibrium (CGE) models. I-O models describe the flows of products from one sector of the economy to the others, and the value added in each (including expenditures in capital, labour, taxes and imports). The CGE model is more sophisticated and flexible. It allows for input substitution, incorporation of price effects, and inclusion of resource constraints.

Market losses are losses to goods and services traded on the market, for which a price exists. *Non-market* losses include all damage that cannot be repaired or replaced through purchases on market" (Hallegatte and Przuski 2010). The social effects of WS&D (see also the chapter 4) on individuals and communities belong to the latter category, the so-called *intangible* impacts. The health consequences of natural hazards, such as injuries, stress or in extreme case deaths (as a result of e.g. heat waves) are the most obvious social impacts; intangible and difficult to monetise. The *environmental* impacts of drought should be taken into account in the assessment of drought impacts. The Water Framework Directive (Art.9) requires that resource and environmental costs are taken into account in the cost-recovery. The environmental costs as defined as "*the costs of damage that water uses impose on the environment and ecosystems and those who use the environment (e.g. a reduction in the ecological quality of aquatic ecosystems or the salinisation and degradation of productive soils)"* (Brouwer and Strosser 2004). Resource costs are defined as *the costs of foregone opportunities which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g. linked to the over-abstraction of groundwater)* (Brouwer and Strosser 2004).

Rose (2004) stressed two main issues in the classification of losses due to natural disasters. A first issue is to avoid the *double counting* of *stocks and flows* and other goods and services because the value of an asset (stocks) is the discounted flow of its net returns. The double counting of goods and services would consist of assessing an effect on both parties: a producer and a consumer for example. Moreover, the second point made by Rose, is that flow measures are more representative of the cost of the disaster than stock measures as stocks are measured at a single point in time and do not represent the disruptive effects of the hazards. Flow values also enable the time of disruption and recovery of the activity to be captured.

The *cost of adaptation* to droughts should also be included in the assessment. These costs can result from the implementation of risk prevention, preparedness or response. The costs of prevention is an investment (to improve infrastructural and societal resilience) with positive return in terms of job creation and reduction of future losses. In response to the 1988-1990 drought in the Basque Autonomous Country (BAC), programs were put in place to increase the water supply from groundwater. The costs of drought responses aim at alleviation of hardship or worst impacts. For example, in the case of the 2008-09 drought in Spain/Barcelona, the costs of response measures imposed amounted to 42 million Euro but the effectiveness of them was rather low. The shipping of water (32.59 Euro/m3) from France was about fifteen times higher than the cost of headwater cisterns (Martin-Ortega et al. 2012).

Economic costs of drought and water scarcity are often ill-conceived, underestimated and incomplete. The EM-DAT Global Disaster Database lists only 26 drought events that occurred in the now Member States of the European Union (EU27+ Croatia) since 1976 (the date of the earliest entry). *None of the events analysed by Water2Adapt is reported in the EMDAT database*. The economic impacts are reported for 19 events and include primarily the foregone agriculture production. The EU Solidarity Fund (EUSF) has been mobilised only once since 2004, in the case of 2008 Cyprus drought.

Climate variability is *endogenous* to agriculture, hydroelectricity generation and other water uses. The drought-related losses should be estimated as the difference between the value generated by a socially optimal (re-)allocation of (drought-reduced) water resources compared either to customary or efficient (if not the same) allocation of water under the average climate conditions.

The scope of the economic assessment should detect the wasteful practices and pave the way to designing (more) efficient schemes, equitable and sustainable management schemes.

3.2 Insights from the Ebro RBD, the part comprised in the Basque Autonomous Country (ES)

The severe drought over the period 1988-1990 in the Basque Autonomous Country (BAC) significantly affected the economy and welfare. Water restrictions were imposed from October 1989 to July 1990. The mandatory restrictions lasted between 6 and 12 hours per day, summing up to 261 days or 2566 cumulative hours. The restrictions were compulsory for residential and non-mandatory for the industrial sectors (Alzorriz 1991).

The estimated economic effects comprised direct (tangible and intangible) welfare losses and adaptation costs. The economic losses for residential and industrial sectors were measured in terms of welfare changes (Garcia-Valiñas 2006). The applied welfare variation method addresses price that consumers would have been willing to pay to avoid the restriction. This (hypothetical) price is higher than the actual price paid for consumption of the service since the resource is temporarily scarce. The difference between actual price and stated willingness-to-pay is employed to quantify the welfare losses.

For the residential sector, the average stated price over the period of restrictions amounted to 5.6 Euro/m^3 or about 5 times the actual water tariffs. Over the ten months-long restrictions the per-capita welfare loss equals to 92 Euro. For the area of Gran Bilbao and Vitoria-Gasteiz (Alava), the overall welfare losses were ca. 83.2 and 18.9 million Euro respectively.

In the industrial sector, the restrictions were not compulsory and the losses can only be guessed. The estimated willingness-to-pay amounted to 5.6 Euro/m^3 in Alava (more than 3.5 times the actual tariff) and 4.6 Euro/m^3 in Gran Bilbao (more than twice the actual water tariffs). The associated welfare reduction was estimated to 136.8 Euro per capita in Gran Bilbao and 876.2 Euro per capita in Alava.

The above shows that the per capita welfare reduction is 10 times larger in the industrial sector than in the residential sector. This explains why restrictions were not compulsory for industrial water use.

In the hydroelectricity generation sector, the losses were estimated in terms of production foregone. The management of the reservoir planned that below a predefined stock of water in the reservoir, the electricity company loses the control of its production and the water is reserved for human consumption purposes. We could not access to the real restriction for the electricity company therefore the losses are measures in potential annual loss in the Zadora system (current prices). The average annual production in Zadorra reaches the 141 GWh (Basque Government 2004) and is by far the larger place to produce hydroelectricity in the Ebro river basin of the BAC (75% of the production). The production value is estimated to 8.6 million of Euros annually.

In the agricultural sector, the marginal productivity of irrigation water has been used to measure the losses of the irrigators. By lack of data, the losses are restricted to the irrigators. The Basque Water Agency has estimated the productivity of water to 0,079 Euro/m^3 (URA 2010). From this econometric estimation we based our analysis. The total consumption of water amounts to 27.6 million m^3. Assuming that this volume could not be applied to the crops, the losses would amount to 101 Euro per hectare that could not be irrigated and 2.1 millions of Euros for the sector.

In the public sector, various set of adaptive measures have been implemented during the drought period. The most important measures consisted in improving the efficiency of the distribution network by repairing the leaks. An investment of 1,2 million of Euro has been provided to that end and it helped to save 200 litres per second or about 5 per cent of the water demand in Gran Bilbao. The other main emergency measure in reaction to the event has been the substitution of water source. 42 millions of Euros were inverted in order to explore groundwater resources possibilities to substitute the superficial stock of water of Zadorra.

The non-inclusion of drought risk in the management of water locally and globally would increase the vulnerability of the economy and the society to climate risk and costlier adaptive decision taken en reaction. Drought risk anticipation measures would prevent some welfare losses and improve the preparedness of the society to drought in a climate change context.

3.3 Insights from the Po RBD (IT)

The drought spells during the period 2003-2007 affected agriculture, hydro- and thermoelectricity production, and water supply and sanitation services (WSS), each in different way.

Compared to the 2000-2010 average, the crop yield per hectare declined in the 2003 and 2007 drought years up to double-digit percentage. The production losses were not distributed uniformly. Generally, higher-altitude areas suffered larger relative losses in 2003 whereas the production in lower-altitudes was more affected in 2007. The production loss varied substantially across the crops, farm type and prevailing irrigation. For example for wheat, the per-hectare yield declined proportionally to the long-term average yield, with exception of few agricultural regions (RA) (unit of ca. 500 km² size with homogeneous production conditions), located in higher altitudes that suffered disproportional losses (Figure 6). However, the economic impacts of drought in 2007 were moderated by substantial increase of crop prices.

The econometric analysis performed on the Italian FADN (Farm Accountancy Data Network) dataset on 3,088 farms in the Region Emilia Romagna (RER), and accounting for (exogenous) climate variability (temperature and precipitation), demonstrated that that agriculture experienced more losses in 2003 than in 2006-07. The model addressed yield of maize, wheat and sugar beet and took into account farm's income, cultivated surface land and on-farm employment. In 2003 the modelled wheat production decreased by 10 per cent and maize by almost 5 per cent. Farm average income declined by 6 per cent and labour demand increased by 28 per cent. The latter is explained by increased UAA (utilised agriculture area) and extended irrigation. In 2007, farm's average income increased by 13 per cent, due to increased crop prices and auto-adaptation, land use extension increased by 18 per cent and labour decreased by 21 per cent (PREEMPT, 2012).

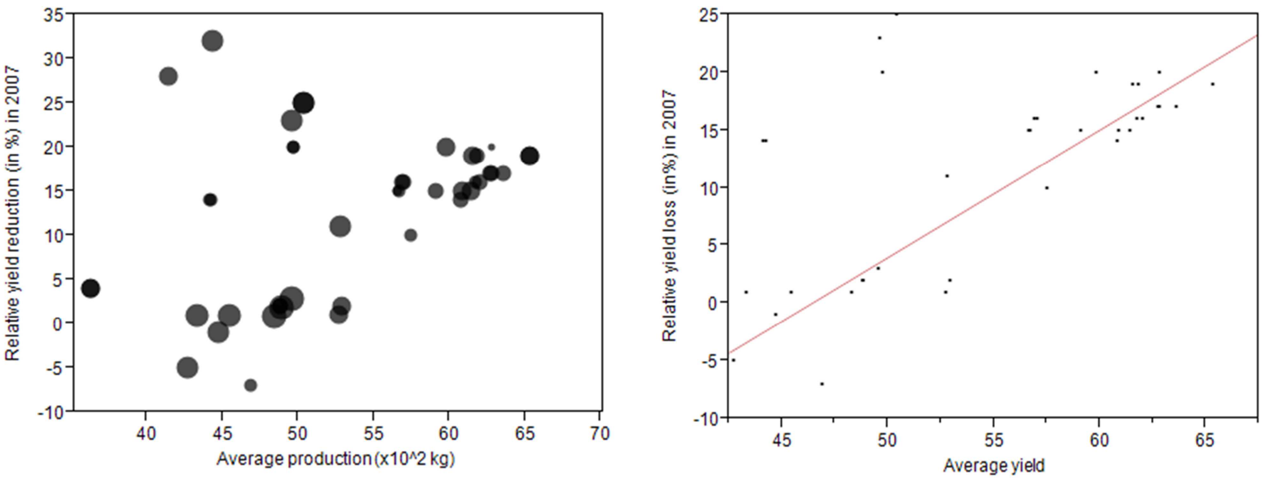


Figure 6: Wheat (relative) yield losses in 2007 compared to average production by *agricultural regions* (RA); (left) all RAs, size of the bubble reflect the relative yield losses in 2003; (right) simple regression model explain 2007 yield losses relative to the average long-term yield (y= -51,25893 + 1,1053933*x; R^2 = 0.86.

A second econometric model based on database FADN for the Po river basin, using a single variable, HCB (hydro-climate balance), calculated with precipitation and potential evapotranspiration, provided more understanding about the agriculture sector response to drought events in the basin. The results showed that the three indicators selected, production, income and labour, have different reaction to water stress depending on the season and the intensity of drought. Drought during winter period for example, could affect negatively production and income, but does effect labour. Because of auto-adaptation strategies of the sector, and price market mechanism, higher temperatures may positively affect production of spring crops. However drought generally have a negative influence on labour, reducing the labour demand. The model confirmed that on-farm auto-adaptation in terms production techniques, crop choices, technological change and reduction of production areas can substantially reduce the losses to droughts (De Salvo and Mysiak, forthcoming). Other studies such as Massarutto and De Carli (2009) have shown that at least partly the crop yield losses were eventually transferred to the consumers, through increase process of agriculture production.

The energy sector has evolved substantially over the last decade. The installed capacity of thermoelectric energy (TE) production in Italy increased by 40 per cent and the hydroelectricity (HE) by around 7 per cent. A half and a third of the respective new capacity development is situated in the Po-RBD which accounts for about 50 per cent of national TE and 30 per cent of HE production. The prolonged drought period 2002-2008 has sparked concerns about the energy security in Italy (2002, 2003, 2007) driven by insufficient amount of water available for cooling of large TE-plants. FEEM research has demonstrated that the undifferentiated support of renewable energy sources (RES) has led to a disproportionate concentration of installed capacity and increased the systemic risk of production breakdown in cases of droughts as experienced in the 1990s and 2000s. The estimated cost of foregone energy production amounted to 280 million Euro in 2003 and 670 million Euro in 2007.

3.4 Insights from the Weser RBD (DE)

To date, no comprehensive post-event assessment of the drought impacts in the Weser RBD has been undertaken. Hence, it was not easy to trace down the economic impacts of drought. However, it is apparent that agriculture was the sector that suffered the most direct losses during the droughts of 2003. It is also possible to estimate at least the magnitude of the losses for this sector more easily than other sectors through an assessment of agricultural yield data, with some assumptions concerning the costs of inputs and market prices.

The most effective response in the agricultural sector in the Weser Basin is the implementation of irrigation systems, which are likely to become more essential for farming as water scarcity during growing seasons increase. With the annual agricultural data available it is possible to determine the economic losses in this sector. It is assumed however that all farms suffered the same impacts from the drought events and had the same production costs (e.g. seeds and other inputs) for the same crop type. Furthermore it was assumed that the operation costs (e.g. labour, insurance, leasing of equipment, etc.) were the same as an average year, and that there were no market price fluctuations.

In 2003, the Weser river basin experienced a reduction in agricultural yields for wheat and other grains, in comparison to 2009 (NLS, 2004). The year 2009 has been used as an average year for agricultural production. Non-irrigated winter crops as well as the root crops are affected by water scarcity. Harvest losses have been estimated in the range of 5.6 to 29.9 per cent in the case study area of "Heidekreis" in a comparison of 2003 to 2009 yields. Looking at the monetary losses per hectare the maximum was 947 Euro per hectare for sugar beets, followed by 471 Euro per hectare for potatoes and 434.4 Euro per hectare for winter rape. Losses for winter-sown rye were minimal, because it's water requirements are less than other grains such as wheat and barley. Spring (malting) barley had a higher yield in 2003 than in 2009, because malting barley often is an irrigated crop. However, monetary losses per hectare in 2009 were a result of a combination of low yields and high input costs per hectare.

The estimated economic cost of the drought of 2003 to the agricultural sector in the Weser river basin was approximately 370 million Euro when compared to 2009 (see Table 1). The losses were mainly in grains and in meadows and pastures. One major crop that enjoyed high yields in this year was sugar beet, an irrigated crop that likely benefited from the warm summer and early autumn months.

Weser RBD	Total cost (million Euro): 2003 compared to 2009

County/District	Grains (50%)	Potatoes (4.8%)	Sugar beets (4.3%)	Winter rapsseed (3.4%)	Meadows & pasture (28.9%)
Braunschweig	-42.522	-12.770	+60.551	-24.502	-29.268
Hannover	-36.310	-41.559	+46.134	-25.864	-34.151
Luneburg	-15.408	-59.744	+27.247	-17.936	-86.622
Cloppenburg	-4.455	-5.745	-	+0.014	+0.077
Friesland	-1.249	-	-	-0.460	-13.106
Oldenburg	-1.750	-5.325	-	-0.661	-2.826
Vechta	-7.656	-8.144	-	-0.704	-2.042
Wesermarsch	-0.479	-	-	-	-22.258
Total	-109.833	-133.289	+133.932	-70.166	-190.199
Total cost (million Euro)					**-369.505**

Table 2: Costs of 2003 drought compared to 2009 (data adapted from NLS 2003, NLS 2009, BMELV 2012).

Although no reports of restricted water availability were reported in the Weser in the summer of 2003, it is possible that low water levels and/or higher water temperatures required adjustments in water cooling and other industrial processes in the Weser River Basin. On the Intschede River in the central Weser, an extremely low water level of 20 cm was measured in September 2003. Despite this low level this condition did not results in any reported problems for inland shipping. In the middle Weser basin shipping occurs only on the Weser itself and not its tributaries. In the upper Weser navigation is assisted with the support of hydroelectric dams (interview, Schulze, 2011) and canalization.

Drought can also have a significant impact on the energy sector when there is insufficient water for cooling and processing. This may be aggravated by increased electricity consumption on warm days as a result of an increased use of fans, ventilators and air-conditioning systems. However, the statistics for electricity consumption demonstrate no noticeable increase in electricity use in Germany in the summer of 2003. There are 17 power plants (including hydroelectric power) and three nuclear power plants located in the Weser RBD. The Norwegian company, Statkraft, owns several water power plants in the Weser Basin including hydropower, wind power and gas power. A study of the German Electricity Association (VDEW) reported a 17 per cent reduction in hydro power production in April 2003 and 14 per cent in May 2003 due to lower water levels (strom-magazin 2003). However it should be noted that electricity prices can be increased in times of drought (i.e. periods of lower productivity), as power companies pass their costs onto the consumer.

Droughts can also have direct and indirect economic impacts at the household level. Domestic water prices may increase due to restricted supply and increased demand for lawn watering. Gardeners, in particular, may suffer from a loss of well-being and possibly income if they grow food in their gardens. In the case of the drought of 2003, there were no reported water restrictions imposed. However no evaluation has been undertaken of the impacts of the drought in the city of Hanover.

4 Social effects of water scarcity and droughts

4.1 Synthesis across the case studies

Social impacts of drought are mediated by a host of factors, commonly referred to as social **vulnerability** (Cutter and Finch 2008; Stehlik and Costello 2008) and **resilience**. Contemporary drought risk management seeks to identify sensitive groups that are less likely to respond to, cope with, and recover from drought. In doing so, we consider communities as part of social-ecological systems (SES) whose interdependences, that is the interconnections between the social processes and the ecological and physical system, have to be taken into account. Walker et al. (2002) and Walker and Salt (2006) recognize that the first step in analysing resilience is to gain a deeper understanding of the SES under examination. Especially rural communities are generally considered to be harder hit by drought and human-made water scarcity. In Australia, farm work-load increases, workers are laid off and farmers have to look for additional income off-farm. Financial hardship and anxiety about future prospects strain family life and increase isolation. Health effects are the combined consequences of "stressors breaking through personal defences" (Dean and Stain 2007).

In areas affected by limited water resources, the social effects of drought and water scarcity manifest themselves in almost every aspect of individual and social life, including nutrition, education, life satisfaction and well-being, social cohesion and order, relationships, population displacement, and public safety. They are difficult to trace and report, being for the most part intangible, unobserved and/or little understood. It is widely recognised that the water scarcity and drought management requires a step-wise shift to more socially-oriented responses addressing "personal, family, farm and community well-being" (Drought Policy Review Expert Social Panel 2008). In Europe the social impacts of droughts are mainly manifested or acknowledged in the farming sector. Nevertheless, with the prospect of increased frequency and intensity of drought events in particular in the Southern Europe, the droughts are likely to affect urban communities.

Normally at the first sign of an impending water shortage within an urban setting water restrictions are imposed. These restrictions can be applied in various ways: by placing limits on the volume of water that can be used, the timing of its application, and/or its purpose. An advantage of a compulsory water restriction is that it can produce significant water and cost savings. However, the imposition of such measures can significantly affect quality of life and contribute to impacts on human welfare. In addition, any savings to the water distribution company and/or municipality may be offset or surpassed by the significant costs of enforcing the restrictions. These so called welfare losses may include, for example, deterioration in the condition of lawns and gardens, and additional costs for new watering systems (e.g. drip irrigation). Australian studies have demonstrated that droughts also have negative effects on mental and physical health, and can result in deterioration of social networks and family life (Edwards et. al. 2008, 2009).

The potential direct and indirect social impacts of droughts can be summarised as follows (Meyer, 2007, Parker, 2005, Lamothe et. al. 2005, Expert Social Panel, 2008): stress as a result of the event itself; physical health effects (in extreme cases if water is scarce or quality is reduced); conflicts between water users; disruption to daily life in the home and in the community; loss of community and/or cultural heritage; loss of landscape and nature as an aesthetic value; and reduced quality of life.

To monitor the progress in achieving the 2020 Strategy in terms of inclusive growth, the composite index *people at risk of poverty or social exclusion* (RPSE) is collected by Eurostat. The index combines three indicators: *At risk of poverty* are persons with an *equivalised* disposable income below 60 % of the national median equivalised disposable income (after social transfers). *Material deprivation* relate to nine deprivations items, among other the ability to pay rent or utility bills. People are severely materially deprived if they cannot afford at least 4 out of 9 items. Finally, the indicator *households with very low work intensity* refers to those aged 0-59 living in households where the adults (aged 18-59) work less than 20 per cent of their total work potential during the past year (Eurostat, 2013). The indicators, collected by Eurostat at the regional disaggregated level higher than that of the analysed rural districts (Nuts 2 rather than Nuts 3), is available for the period 2004-2011 only for Spain and Italy. The RPSE for *Pais Vasco* (Spain) and *Emilia Romagna* (Italy) are both much lower than national level, confirming the relative wealth of the case study regions compared to the rest of the country. In both region they appear to respond more to the economic and financial instability of the countries after a period of steady (Emilia Romagna) or decreasing (Pais Vasco) levels.

In general, it is difficult to disentangle the impacts of drought on social wellbeing of households from other strains, including the economic and financial turmoil. Still, the social impacts of drought in Europe are very different from those reported in Australia. Due to high accessibility and economic diversification, the rural regions are better equipped to cope with drought. The European Agricultural Policies provide a stable income basis independent from the crop yield and rural development programme provide a development aid. However, besides the direct influence on social wellbeing, drought contributes to temporary or permanent decline of environmental quality and ecosystem service provision which also disproportionally harm he rural communities.

4.2 Insights from Ebro river basin of the Basque Autonomous Country

The province of Alava, in the Ebro river basin of the Basque Autonomous Country, is defined as a rural area by the Rural Development Plan of the BAC (2010). Some 98 per cent of the territorial units are rural and account for 14 per cent of the population.

The economy of Alava is driven by services and industries, accounting for 56 and 34.5 per cent of the regional GDP. The activities are not uniformly distributed in the territory. The services are dominantly represented in the Llanada Alavesa and Montaña Alavesa. The industries dominate in the rest of the six sub-provinces. The agricultural sector is nowhere the dominant sector but is more represented in the Rioja Alavesa known for the wine production.

The agricultural sector is highly exposed to meteorological droughts. During the drought situation of 1988-1989, about half of the farmers of Alava reported some difficulty with water provision, compared to only 15 per cent some ten years later (Eustat 1989, 1999). Despite the small weight on the regional economy, agriculture plays an important role for the society through the management of environmental services, food and timber provision, cultural services (agro-tourism developed by the wine sector in the Rioja Alavesa) and land maintenance. Prolonged droughts and desertification puts these services at risk. To combat the impoverishment of rural areas, the government has promoted action programmes to (i) increase value added of productions and wealth, (ii) diversify services and economic activities, and (iii) counteract the demographic imbalance and population aging. The reason to concentrate on these area is that a more efficient sector makes better to allocate scare resources (environmental or financial resources), a richer sector makes better to face environmental or financial risks and can support the cost of diversification, and a age-balanced population enables to sustain the services in the time.

The Rural Development Plan (2007-2013) had been designed to promote jointly economic efficiency with a sustainable use of natural resources. The European program LEADER and the National Strategic Plan finance measures in favour of the rural communities. These measures are related to the management of water for 4 per cent of the total budget, 57 per cent to the improvement of the value added of products, 13 per cent to the installation of young farmers and 10 per cent to biodiversity protection.

In urban context, the drought of 1988-1990 gave rise to water restrictions between 6 and twelve hours per day during 10 months for the households sector. Life quality and health have been inevitably altered. Our estimation of the associated well-being losses amount to 92 Euro per capita, 102 million Euro for the community.

4.3 Insights from Po river basin (IT)

Over centuries, the Po lowland had been by and large developed, forming an prolonged metropolitan area that extends from Venice in the Northeast until Milan, and with minor interruption until Torino in the Northwest, and back following the ancient *Via Aemilia* (in Italian *Via Emilia*, completed in 187 BC and connecting *Ariminum*, now Rimini, on the Adriatic coast with *Placentia*, now Piacenza) back to Bologna in the Southeast. The province of Piacenza is the only break of the extend metropolitan area between Milan and Bologna. A detailed Eurostat urban-rural classification distinguishes provinces of Piacenza (PC) and Ferrara (FE) as the only predominately rural provinces in the Emilia Romagna region (RER). The Italian classification of rural and urban regions, which applies the altitude and the degree of local specialisation in farming activities in addition to population density, distinguishes three classes of rural: *rural areas with specialised, intensive agriculture* (RRSIA); *intermediate rural regions* (IRR); and *rural with comprehensive development problems* (RRDP). This latter category, encompasses around 60 per cent of the territory of PC and 57 per cent of the population (PRIP, 2007). The city of Parma and the surrounding municipalities are classified as RRSIA and the whole province of Ferrara, including the capital city, as IRR.

Until 2004, the water supply and sanitation (WSS) service in the municipalities of PC belonging to the RRDP category were served wither by in-house or, for a small proportion, by municipally-owned enterprises (*Consorzio Val d'Arda* and *Consorzio Val Nure*). The wastewater treatment of some in-house served communities was provides by *Tesa*. In 2004, in the course of WSS reform, the *Tesa* (later transformed into *Enia* and successively *Iren*) became the only water utility for the whole province of PC. *Iren* is also serving the Parma city and *Hera* (in the past Acosea) the Ferrara city.

Italy is one of the least rural countries in the EU, characterised by above average GDP per capita in the rural regions that are well connected to connected to urban poles and networks of small and medium-sized cities (such Piacenza, Parma, Reggio Emilia and Modena in RER) (OECD, 2009). This results in a higher diversification of economy and lesser dependence on agricultural output. The EUROSTAT/OECD classification of rural regions at province level however disguises the intra-provincial differences that are better captured by the nationally designed urban-rural typology. Especially the disadvantaged and economically marginalised RRDP areas display a number of development issues, ranging from negative demographic balance, population aging and poorly developed and maintained water infrastructure. They have experienced interruption of water service during the droughts, and for several months water has been supplied by water tanks.

The wider social impacts of drought are obfuscated by compounding factors and arguably more important factors such as economic downturn. The social indicators of stress including *being at risk of poverty or social exclusion* are collected at provincial level and hence are not representative of the social hardship the RRDP municipalities are exposed to. The WSS provision is obstructed by a legacy of poor infrastructure development and maintenance and higher prices than in the rest of

RER. The income before taxes is lower than elsewhere, increasing the economic vulnerabilities of the households. The drought spells were too short for either affecting the structure of the population or bringing about health issues.

Cooperation and intergeneration developments are undergoing substantial changes. Employment opportunities, market, and education levels seem to be the main drivers of the change. Although droughts revitalised old forms of cooperation for water management, and although some surely still collaborate (biogas farmers, farmers belonging to the same union, and so forth), their effort does not seem to focus in this direction. The Land Reclamation and Irrigation Boards (in Italian *Consorzio di bonifica*, CDB) appear as coordinating body of individual initiatives. Collaboration between different groups (farmers, residents involved in non-farming activities, tourism developers and tourists themselves) seems very narrow, despite Local Action Groups and other recent initiatives who are trying to bring them all to plan towards similar goals. The analysis performed at rural level shed light on on-going auto-adaptation process of communities. This autonomous adaptation increased the resilience of the sector to drought for the following reasons: 1) farming technologies improved efficiently, increasing the agriculture total surface and decreasing working intensity per hectare; 2) irrigation intensity increased, together with the development of alternative sources of water (groundwater); 3) energy production (biomasses) was introduced in the farming business, providing and alternative source of income.

At urban level, increasing urbanization, changing in the demographic composition and the legacy of underinvestment in water infrastructure pose the water supply ad sanitation under strain. Neither Parma nor Ferrara (core cities) experienced significant water restrictions midst the water crises in 2003 and 2006-2007. However, the drought spells revealed both cities' vulnerabilities to major and lasting drought events. The public water supply in Parma is provided from groundwater, thus the effects of drought are delayed and short-lasting drought events may not lead to immediate water shortages. However, the average annual water deficit, that is the difference between groundwater recharge and abstraction rates under normal conditions, exceeds 1 million m^3. In long term, the deficit may turn into a major problem of water provision. In August 2007, the local administration declared water restrictions limiting the use of water for watering and car washing in some suburbs of the Parma town, employing tank-lorries to guarantee water supply. The monitoring and enforcement of the restrictions were overseen by police, and inhabitants were encouraged to monitoring the application of the regulation. In the past, several urban wells were rehabilitated, reducing the losses by 330,000 l/day per well. Indirectly, the water conservation measures translated into less energy consumption needed for pumping and treating waters.

Ferrara urban water supply is guaranteed from the Po river. During the drought events in 2003 and 2006-2007, the river level fell below the abstraction point. To guarantee the water supply it was necessary to make structural changes at the abstraction devices. Still, the water diversion for the town (on average 1,040 l/s) accounts for a small proportion of the river flow (average minimum 300-350,000 l/s) even under drought regime (environmental flow: 240,000 l/s). The water supply was not at risk because of low water flow, but because of inadequacy of water abstraction devices initially not designed for low water years such as those in 2003 and 2006-07. The interviewed stakeholders pointed out to the drought inflicted water crisis in the tourism dominated Romagna coast supplied by the *Ridracoli* dam, where in 2007 and more recently in 2012 the reservoir experienced critical level of exploitation.

As it appears, despite the severity of the 2003 and 2006-7 drought events, cities in the Po RBD were affected in a limited way. Drought is still a concept that few appreciate in their daily business, and it will probably not be appreciated before personally feeling water shortage from the tap. Surely, in Ferrara the discourse of preparation to drought and other extreme water crisis is more developed than in Parma, primarily due to the former's history and location. However, such events are deemed unlikely by water managers in both areas. Nevertheless, the fact that citizens did not perceive any significant changes in water delivery patterns does not exclude that the impacts are negligible. The area of Romagna particularly, which is not directly included in the Po river basin but fetches its water from the Po river, suffers from a recursive problem of water scarcity, which, with deteriorating water quality and climate change, could be experienced elsewhere in the basin.

4.4 Insights from Weser river basin (DE)

The effects of water shortages on the farm business depend on environmental conditions and farmers' capacity for adaptation to water shortages. In the district of Heidekreis, the team interviewed 21 farmers. Table 3 presents factors that have had a positive or negative impact on social resilience with reference to a number of key indicators for the case study area. To evaluate the social resilience of farmers in water scarcity situations, it is necessary to consider environmental factors as well as social factors. The table presents indicators that may have an impact on social resilience. The bold numbers in brackets are the number of farmers who are affected by the conditions (indicators). It refers to farmers who have a farm as a primary business. From the survey it is clear that at least those farmers interviewed have a relatively high level of social as well as economic resilience.

Positive factors	Negative factors
Landscape	**Landscape**
high soil quality index **(8)**	low soil quality index **(12)**
large part of cultivation of farmland	high land demand
more than 60 per cent of farmland is owned **(10)**	high irrigation costs
effective (electrified) irrigation **(7)**	no adaptation to drought events **(0)**
well-structured farms (farm size larger than 125 ha in SFA average) **(15)**	
measures adapted to droughts **(20)**	
Social	**Social**
professional education **(20)**	no professional education **(0)**
good cooperation with colleagues **(19)**	little cooperation among colleagues **(1)**
good advisory support **(20)**	low importance of holidays **(2)**
diversification of income **(17)**	no external advisory support **(0)**
good experience with energy crops **(13)**	fewer leisure activities **(2)**
importance of holidays **(18)**	fewer holidays **(2)**
non-professional activities **(19)**	no non-professional activities **(1)**
feel represented by policy **(10)**	do not feel represented by policy **(10)**
farmers in political positions **(2)**	farmers not in political positions **(18)**
acceptance of non-agricultural neighbourhood **(13)**	insufficient acceptance of non-agricultural neighbourhood **(7)**
structural change: successor **(14)**, future plans **(7)**	

Number in bold = number of farmers responding

Table 3: Natural and social factors affecting social resilience of farm businesses.

Drought events, until now, appear to have had no measurable impacts on the social well-being of individual farmers nor that of surrounding communities within the district of Heidekreis. Only farmers with an irrigation system indicated that they suffered more stress during irrigation periods, as a result more intensive reliance on the system. Agricultural statistics of 2003 to 2010 also do not indicate any significant changes in social resilience (shrinking population, reduction in number of farmers or decreasing farmland) in comparison with seasons with more precipitation. Water consumption and prices also do not reflect the water shortage situation. Losses during a drought vary by crop type since market conditions for food commodities vary significantly from year to year. It would therefore be sensible to assess of the economic and social impacts of drought on farmers according to their dominant crops.

Although all interviewees indicated an increase of drought events in the last ten years, none were overly concerned about water shortages. This is due to the fact that they have, until now, not been strongly affected by water shortage situations. Some of them even said, that water shortages are artificially constructed implying that the government wanted to give the impression that there is a water shortage although there is none. However, to demonstrate this further investigations would be necessary, by for example, monitoring investment by farmers in irrigation systems.

Urban areas in Germany are normally less quickly and less directly impacted by drought and water scarcity than rural areas, mainly because the latter often support agriculture, forestry and other natural resource-based activities. In the urban context and specifically in the case of droughts the following impacts are most relevant:

– stress as a result of the event itself, linked with health problems and loss of life due to associated heat waves especially among the elderly and sick;

– loss of property or value of assets (e.g. gardens, urban market gardens)

– loss of local labour and increased working hours (especially on farms)

– loss of landscape, parks and other green areas as an aesthetic value;

– reduced quality of life in terms of welfare losses due to reduced opportunities for leisure and recreational activities.

– The main environmental and ultimately social impact of drought conditions on the urban space are water and air quality. An increase in air and water temperatures during summer seasons, water shortages and reduced water quality as well as reduced air quality can lead to a wide variety of primarily negative effects on urban life.

As mentioned earlier a drought can have direct and indirect economic and social impacts at the household level. Domestic water prices may increase. If water restrictions are imposed, daily life is interrupted. These restrictions may be limited to lawn watering and car-washing, but nonetheless can influence human welfare negatively. According to the public utility of Hanover, the main drinking water supplier for the region of Hanover, is not jeopardised by the incidence of a periodic drought as the groundwater-based water supply is secure for up to four consecutive years (Interview, Fürstenberg 2011). Efforts to encourage water-saving behaviour of households may actually be counter-productive since pipelines can temporally fall dry causing hygienic and eventually health problems (Interview, Fürstenberg 2011).

Urban gardens and allotments have a significant function in terms of improving the quality of contemporary urban life. The city of Hanover has more than 20,000 gardens. Most of the owners are members of gardening clubs or related social networks. A drought may hamper gardening activities or even caused allotment owners to abandon their gardens for the season. Together with a loss of the aesthetic value of green space or the loss of its function as a temperature buffer during a hot spell, the decrease of gardening activities can cause emotional stress and a reduction in quality of life. So gardeners, in particular, will suffer from a loss of welfare and eventually income if they cultivate fruit and vegetables in their gardens. In the case of the drought of 2003, there were no water restrictions imposed and the associated heat waves did not appear to lower quality of life according to local authorities. However there were no studies done to assess these impacts.

Recreational fishing is a popular leisure activity that provides a unique experience with nature, and has, due to the existence of many clubs and associations, a strong social and integrative function. Low levels of surface waters result in an increased growth of phytoplankton and zooplankton as well as pathogenic germs. Hence the water quality declines with negative implications for the recreational function of the waters (BBSR 2009, 22). A long lasting drought can therefore reduce the nature experience as well as associated social exchange that it contributes to.

The interviews with representatives of the City of Hanover revealed that rather than water scarcity, the more significant issue during the drought was the associated high temperatures and heat waves. The implications of heat problems are higher in urban than rural areas because of the heat absorbing capacity of pavement and buildings. Furthermore, buildings block the ventilation of the urban space, and heat islands are generated. It has implications for residents in terms of their use of public open space, but also for their level of comfort with the occurrence of several consecutive days or weeks of high temperatures. Furthermore the elderly and infants suffer more during heat waves.

In general, data on the social impacts of droughts are scarce. Interviews with city representatives in Hanover revealed mainly ecological impacts such as decreasing groundwater tables, diminishing or even the drying-up of surface water bodies, eutrophication and resulting fish mortality, losses of wetland habitat and/or decreases in biodiversity (Interview, Pyka 2011).

5 Ex-post review of the drought risk mitigation measures in place

5.1 Synthesis across the case studies

Regulatory, planning and economic measures play a central role in the risk mitigation and adaptation to likely impacts of climate change. The Water2Adapt team analysed the measures and policies in place or potentially applicable. Strengths, weaknesses, limitations and performance of the analysed instruments were assessed and described for each case study.

The Spanish team analysed emergency regulatory measures, such as temporary civil supply water restrictions, that curbed the water consumption by up to 30 per cent. Moreover, the team addressed water tariff systems, whose volumetric component is able to incentivise water saving, and the control mechanism for water accumulation levels.

The Italian team analysed drought risk and water governance in the basin. The review concluded that the coordinated management during the period of drought spells, embodied in the *Protocol of Intent*, made it possible to reduce the drought related losses. However, a major reform of water entitlements the country's renewable energy strategy was needed. The on-going revision of *Water Balance Plan* is a good opportunity to set out new principles for granting and renewing the water abstraction licences. The newly introduced Drought Early Warning System (DEWS) operated by the River Basin Authority is an example of best practice. Economic and financial policy instruments, including water tariff systems for domestic and agricultural uses, and the structural investments through the *National Irrigation Plan*, were analysed.

Regulatory and regional planning measures were also addressed in the German case study. Volumetric water tariffs are successfully implemented as water demand management tools in the domestic water supply and in agricultural. Unlike the Ebro and Po river basins, environmental costs are internalized through wastewater discharge fees. In addition, the Weser team analysed urban planning measures for mitigating effects of heat waves, and construction of rainwater retention areas.

Field	Description	Ebro	Po	Weser
Planning	River basin planning instruments	x	x	x
Planning	Urban planning instruments (green areas)			x
Planning	Water Balance Plan		x	
Planning	Water Act			x
Regulatory	Coordinated water management		x	
Regulatory	Domestic water restriction	x	x	
Control	Revision of water monitoring instruments	x		
Control	Drought Early Warning System		x	
Economic	Water tariff system (domestic)	x	x	x
Economic	Water tariff system (agriculture)	x	x	x
Economic	Wastewater tariff system			x
Mitigation	Improved irrigation efficiency			x
Mitigation	Rainwater harvesting (urban)			x
Mitigation	Financial instruments for improved irrigation (e.g. National Irrigation Plan)		x	
Mitigation	Insurance mechanisms	x		
Mitigation	Solidarity funds		x	

Table 4: Drought ad water scarcity mitigation measures reviewed in different case studies of the project.

5.2 Insights from the Ebro river basin of the Basque Autonomous Country (ES)

During the 1988-1990 drought, severe restriction have been put in place to ration the limited water resources in the Zadorra system. Water restriction and rationing are the ultimate measures adopted by water managers (CABB 2010), unpopular for the government and costly for the users (W2A 2012a). The restrictions lasted from October 1989 until July 1990 enabled to conserve substantial volume of water (table 6), under deep uncertainty about how long the drought would persist.

Period	Daily water restriction period	Water savings
October 1989	0 to 6 am	10-15 per cent
November 1989	22 pm to 6 am	15-20 per cent
December 1989	21pm to 6am	20-22 per cent
January 1990	18 pm to 6 am	25-30 per cent
February 1990	18 pm to 6 am, plus days off	30-32 per cent
March & April. 1990	18 pm to 6 am, plus days off	20-25 per cent
June 1990	22 pm to 6 am	20-25 per cent
July 1990	0 to 6 am	10-15 per cent

Table 5: Water restriction during 1988-90 droughts

The restrictions became more severe with the intensity of the drought dwindling stock of water in Zadorra reservoirs. According to the CABB estimates, the volume of conserved water was determined by the duration of the restrictions, the period of the restriction during the day, and the period of the restriction during the year. A 12-hours restriction in a month may result in about 30 per cent reduction of consumption. A 8-hours-long restriction in June conserves more water than the same restriction in November, because of the seasonality of water consumption. The current Drought Emergency Plan of Bilbao (CABB 2010) foresees restriction and estimates the conservation rates based on the previous experiences. In an initial phase, the restriction are set to reduce demand by 7.5, whereas in the more intense drought phases, the target is set to 15 per cents. Overall, the restrictions should not reach the levels of 1989-1990 thanks to the improved management of the water system.

During the 1988-1990 drought, the management of conjunctive uses of the reservoir for water supply and energy production did not performed well. In the aftermath of the event, the management rules have been revised. The new rules specify various levels of the drought risk and are integrated in the Drought Emergency Plan of Bilbao (CABB 2010).

The water tariff instruments affect water consumption and efficiency. The structure of the tariff is to fulfil three objectives: cost recovery, efficiency and equity in uses. Water utilities apply two-component tariff structure (fixed and variable): the fixed component is independent of the water volume consumed, whereas the volumetric components applies price-increasing block scheme with higher price for water above a certain threshold. The water utilities concerned by recovering the invested sunk costs put more emphasis on the fixed component of the tariff. The volumetric variable component, small in size, provide less incentive for the consumer to change behaviour.

Land use policy instruments are promoted in order to reduce the exposure of farmers to drought. In addition, the state-subsidised agricultural insurance system is an effective instrument in addressing certainty of production and income.

5.3 Insights from Po river basin (IT)

Water and risk governance plays an important role in mitigating the impacts of droughts. The water governance in Italy involves a number of national, regional and provincial bodies whose role and operation is not sufficiently coordinated. The planning instruments such as River Basin Management Plan, the Flood Management Plan, Territorial Development Plan, WSS blueprint, and Water Conservation Plans follow similar objectives but overlap in competences and unclear responsibilities, reducing their effectiveness. In case of case of major natural disaster, calamity or other critical events, the management of the emergency in Italy is responsibility of the National System of Civil Protection, which take over most of operational authority. At regional level, provinces draw the Provincial Emergency Plan and municipalities have the responsibility to prepare the Municipal Emergency Plan. The plans are in accordance with regional guidelines and they are coordinated between them. For each region an Emergency Operational Centre (EOC) is installed for prompt emergency responses.

During the exceptional drought occurred in 2003, the River Basin Authority in collaboration with the Civil Protection Agency have initiated a new instrument, the so called *Drought Steering Committee* and *Protocol of Intent*. In order to promptly tackle with the emergency several authorities (NCDP, Po River Basin Authority, Regions Valle d’Aosta, Piedmont, Lombardy, Veneto, Emilia-Romagna, AIPO, GRTN, lake-discharge Consortia, ANBI and the hydro and thermo-electric plants) signed an agreement for a coordinated management of the (scarce) hydro-resources of the basin. The agreement provided for the release of additional 3.7 million m^3/day from hydropower alpine intakes in order to cope with irrigation deficiencies further downstream. It also provided for the reduction of water derivations for agriculture purposes by 10 per cent from July 17th baseline observations, on all alpine rivers. The measures foresaw a total additional water flow contribute of 8.13 million m^3/day to the Po River body downstream. The Agreement entered into force on July

19th until August 8th, for a total of 21 days The Protocol of Intent produced doubtless positive effects on the water regime of Po River tributaries. Coordinated and integrated interventions at basin level provided to mitigate the water stress along the rivers. Thanks to the measures implemented power generation (thermoelectric) and agriculture production were assured during the drought. It was calculated that the implementation of the Protocol reduced the potential losses from 1.9 billion Euros to 1.3 billion Euros (Massarutto, 2009).

Following this experience the Po River Basin Authority started the production (on-going) of the Water Balance Plan (*Piano di Bilancio Idrico*), which is a permanent tool for the ordinary management of emergency situations such as droughts. The Plan contains the Po River Drought Early Warning System (DEWS-Po), which has been recently developed and is now under testing, with the aim of forecasting, simulating and controlling droughts in the entire Po river basin and providing the competent authorities with useful data for coping with emergency situations. The DEWS-Po system has mainly been developed as a decision support tool for the management of water crisis. For this reason, it is supplied with guidelines that are meant to promote the use of the system when periods of water scarcity arise in order to evaluate the insurgence of droughts, monitor their development, quantify the severity and provide the necessary information for prospective coping actions as well as the formulation of possible scenarios. When available, the Plan will surely be a very useful tool for water management and scarce conditions.

Driven by the drought periods of 2000/1 in the south and 2003 in the centre and north of the country, Italian institutions had to increase their efforts to achieve the efficient use of water. One of the actions implemented to achieve better efficiency is represented by the large investment plans in water-infrastructures adopted by the central government for irrigation purposes and other uses. The coordination of central and local authorities brought to the development of the National Irrigation Plan (NIP), part of a wider National Hydraulic Plan (MPAAF 2010). The final NIP for the period 2007-2010 provided with a series of intervention for 1.1 billion Euro, 770 million Euro for the Regions of central and northern part of the country and 330 million Euro for south and main islands (MPAAF 2010). The main interventions included in the Plan could be summarised as follows: restoration and efficiency increase of the reservoirs and water storage systems; completion of the upstream part of the water provision infrastructures; restoration of the damaged part of the aqueducts; measures aimed to avoid unauthorised withdrawals and reduce losses due to evaporation; renovation of the water distribution network; renovation of measurement and monitoring systems; utilisation of the purified urban wastewater for specific cultures. According to the last data available, on September 2011, an average of 83 per cent of total investment in the main regions of the basin has been accomplished. As highlighted by the Responsible for the Legal Department of Coldiretti, one of the most important farmer associations, water consumption for irrigation in Italy passed from 28 to 21 million cubic meters per year in the period 1995 – 2010. It is realistic to think that the investments brought by the National Irrigation Plan contributed to the achievement of this important reduction in water consumption.

The team analysed the domestic water tariff in Emilia Romagna Region. The instrument have clearly contributed in reducing water consumption in the area of application, raising also, partially, the necessary financial instruments for the maintenance of water infrastructures with the indirect effect of reducing the potential impact of droughts in the basin. In Italy the water tariff system, introduced in 1996, is based on the Normalised Method (NM) and it is set by the water services that are organised within the so called Optimal Territorial Area (ATO). The normalised method assumes tariffs are sufficient enough to ensure that the water companies have adequate revenue to meet their obligations, for instance, make investments in the quality of service, cover capital maintenance costs and depreciation, and a return to capital investments. In general, the tariff consists of a fixed and variable charge, purification fee and sewage fee. The variable charge component is based on increasing block tariffs by taking into account the number of household members. Since 1996 the normalised method of setting the water tariffs was subject to several modifications. A rate of return on the capital invested at the level of 7 per cent was introduced in the calculation of the NM of water tariffs in 2006. Furthermore, in the Region of Emilia Romagna (RER), for instance, the tariff system calculation included an additional component, called performance indicator (PCn), which provides incentives to the companies to improve their quality of service (e.g. unplanned service disruption, customer satisfaction, and environmental standards (e.g. water loss and water consumption). The importance of the introduction of the performance indicator lays on the fact that water companies with high performance are awarded, by allowing increases in their tariffs, whereas utilities that are characterised by low performance are penalised, by allowing reductions in their tariffs. Furthermore, within the RER another modification of the water tariff system was introduced in 2008. The ATO5 of Bologna recently introduced the so called 'per capita' tariff and an additional social tariff, which depend on the number of family members and the household income respectively.

From an water saving perspective the water tariff instrument contributed to levelling water uses across Italy and reducing water demand in some areas. In the period 2000-2009 national average domestic water use in district towns decreased by 11 per cent. National water consumption variability decreased from 36.8-108.9 in 2000 to 35.4-93.6 in 2009. RER district towns have in general average-low rate of water consumption. During the years 2005-2008 Piacenza showed the highest level of reduction (22%) followed by Parma, Ravenna and Modena, 18%, 14% and 11% respectively.

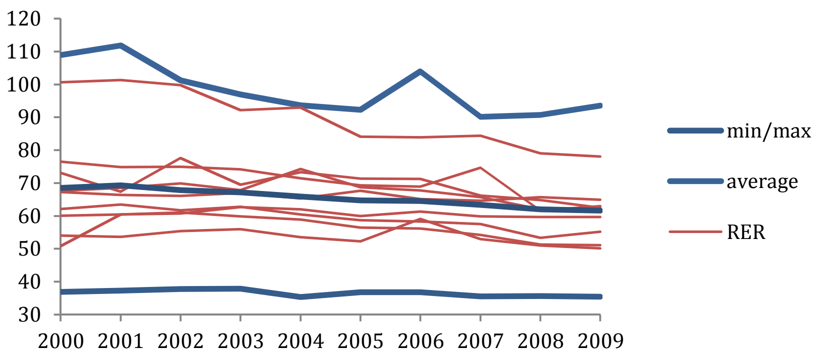


Figure 7: Domestic water consumption per capita trend from 2000 to 2009 in Italian district towns (ISTAT 2009). Red lines are RER towns. Min-max is relative to all Italian district towns.

It is evident from the figure below that RER district town's water consumption variability decreased with increasing cost of water.

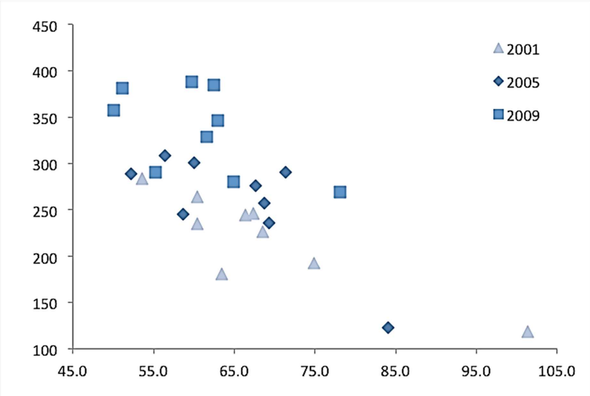


Figure 8: Water consumption per capita (m³) compared to water tariff (price for 200 m³/year) for RER district towns.

From an economic perspective, the introduction of water tariffs in 1996 led to significant increases in customers' bills. It has been estimated that during the years 2001-2010 on average customers' water bills increased by 66.7 per cent in Italy, and 68 per cent in the region of Emilia Romagna, with Piacenza and Parma reporting the highest level of increases. The distributional effects on household affordability were partially compensated by the social water tariff system introduced by several ATOs in RER. The best example is the "per capita" tariff system introduced in Bologna area.

The revenue from the customers' bills was the main source of finance for water utilities, accounting for 46 per cent of the total finance sources, to make capital investments on the water and sewerage infrastructure and improve the supply of service. Although RER reports substantially lower water distribution loss rate (24%) compared to the national average (32%), investments in water supply infrastructure had a positive impact on the network performance in terms of water losses, inducing a further reduction of 2 per cent (2005-2008). The performance indicator (PCn) in the RER tariff system is an example of regulatory innovation which should be further developed, for instance with a collection of a set of service quality indicators.

5.4 Insights from Weser river basin (DE)

Regulatory **basin-wide measures** concerning resource use and management may be prescribed at the international, national and sub-national levels. The regulatory framework for guiding water use in Germany are the Water Framework Directive (WFD) at the European level, the federal Water Management Act (2002) and several other federal acts that can have a role in drought management. At the federal state level the most relevant regulation is the Water Act of 2007**.** At the sub-catchment level, water management plans are developed by the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency, that also makes recommendations for the implementation of plans and measures at the district and municipal levels. The lower water authority is responsible for permit, execution- and supervision of measures that are prescribed by the higher level authorities.

In general farmers are allocated irrigation water for a seven year period, with an average of 70 to 100 mm per year. The water extraction permissions and the required applications are used by the administrative district as a regulatory measure to control and respond to water consumption and negative impacts to groundwater bodies or nature protection areas. To do so it is, in some cases, necessary to submit an hydro-geological report.

The cost of irrigation water is marginal in Lower Saxony. The water fee or "cent" as it is referred to in the **agricultural sector** is less than one cent. In Lower Saxony farmers pay approximately 0.5 cents/m^3 of water. A cubic meter of irrigation water including all services that support the abstraction and supply of irrigation water (e.g. electricity, infrastructure, labour, etc.) costs 15 to 20 euro cents (Fricke 2012). The use of irrigation water is influenced by market prices for food commodities. When prices are higher, profits can offset the extra investment in irrigation water. The fee is not presently set high enough to have much influence on regulating water consumption, but it could become a more effective measure that could reduce water use for irrigation.

Water rates are also an important instrument for water demand management in **urban areas**. The water rate (price per m^3) in Lower Saxony is substantially lower, by about 25 per cent, when compared to the rest of Germany. Conversely, the water consumption in liters per day is about 5 per cent higher than the national average. This suggests that higher water rate would lead to further reductions in water consumption.

Wastewater fees are another means of managing water demand in urban areas by charging a fee for the discharge of treated wastewater into water bodies. This instrument is consistent with the guidelines of the WFD because it serves to internalize environmental costs and provides an economic incentive to minimize wastewater discharge and use water more efficiently. It also takes into account resource-related costs with the aim of providing better treatment before wastewater is released in a German water body.

With the existing formal instruments, regional planning processes in Germany are able to respond to the need for climate change mitigation and adaptation. These formal instruments are: the regional plan, which is the regional development plan (RROP) in Lower Saxony, the regional land use plan (not always in use), environmental impact assessment and the coordination among related sectoral planning organisations and activities. The informal instruments such as networks, regional development concepts and interdisciplinary projects are important for raising awareness of and disseminating information on the impacts of and adaptation to climate change (Wiegand, 2010).

Summer droughts are frequently accompanied by excessively warm temperatures. Consequently densely settled areas need sufficient ventilation when summer heat increases and the urban heat island effect develops. In urban areas, improvements in the climatic balance, especially the development and maintenance of climatic compensation areas for producing cool, fresh air, is becoming a more important theme. The establishment of green belts or green buffer areas can have a cooling effect and contribute to ventilation .

In Hanover, the working group "urban planning aspects" develops measures to mitigate urban heat island effects, heat waves, "tropical nights" and their impacts on the human health. Another working group "water policy / water management aspects" focus on the change in precipitation rates, increases in heavy rainfall events and the resulting impacts on urban drainage and management of increased flood risk. The working group "environmental planning aspects" addresses, among other things, the increase in summer droughts and their impacts on the agricultural and forestry sector, on water bodies and on urban green areas including the supply of sufficient water to city trees. Furthermore, the City of Hanover has introduced several guidelines and instruments e.g. *Guidelines for green roofs* (1994) and *Requirements for storm water management 2007/2009* (with several rainwater drainage practices) to mitigate and adapt to impacts of climate change.

Measures have been implemented in the city of Hanover to increase urban green space and vegetation on roofs and facades through planning and landscaping approaches (Schmidt, 2012).

These measures have the effect of improving the urban bio-climate but can also have the added benefit of reducing urban water use, by, for example, creating retention areas and temporary buffers for rainwater. The collected rainwater can then be redirected so that it percolates into groundwater or into a seepage reservoir.

Several **agronomic measures** have been evaluated for their effectiveness in strengthening resilience to water scarcity in rural areas including mitigation, regulation, economical and retention measures. A "higher-stand density" does not have a positive influence on water efficiency, but mulching maintains/improves soil moisture and the application of the correct amount of manure appears to contribute significantly to more efficient water us, because plants can grow deeper roots. Under climate change conditions, **irrigation systems** will become essential for a greater number of farmers. There is potential to reduce water losses by using efficient irrigation systems. This can be achieved by investing in some of the newer irrigation systems, like a centre-pivot irrigation system or linear irrigation systems.

Large-scale centre-pivot irrigation systems reduce water consumption by up to 20 per cent, reduce water losses due wind driftage, and supply plants more precisely with water. However these water conservation techniques will be offset by more intensive crop rotation with higher water demand. A better implementation of and more efficient precision irrigation systems, such as drip irrigation, where appropriate will be helpful in reducing future water demand for agriculture. However, drip irrigation systems are expensive to purchase and operate and so currently only appropriate for more specialised crops such as asparagus and certain potato types.

6 Future trends in water availability and uses across the case studies

6.1 Synthesis across the case studies

Several studies raised the concern that global changes, like climate change, demographic increase and land uses modification, will strongly impact global water security (Vörösmarty et al., 2000; IPCC, 2007). Climate change effects in the future will affect water availability, temperature increase will increase the magnitude and frequency of extreme events, such as drought. Climate projections over Europe foreseen decreased average precipitation in many parts of southern Europe, particularly in the Mediterranean area, and increase precipitation in northern and north-eastern Europe. Precipitation variability will probably increase, with lower peaks in summer. Changes in land use cover and precipitation patterns will probably change seasonal run-off, inducing lower river flows in summer. Because of this and because of socio-economic changes affecting water demand, water stress will increase in warm seasons along several basins in European Member States (Flörke, 2011).

Several other European project has tackled the issue of water availability and water demand. For example the project ClimWatAdapt (www.climwatadapt.eu) estimated future water availability, according to different socio-economic scenario., The results include Po river basin and Weser among the European basins which have higher annual water withdrawals. The projected socio-economic scenario, provide a wide range of future (2050) water demand, from 25 to 50 per cent increase in Weser and Ebro river basins and from 5 to 25 per cent increase in Po river basin according to the Economy First scenario (a marked oriented scenario), and more than 50 per cent water demand decrease with the Sustainability First scenario (a scenario focussing on the quality of life). Based on this assumptions and through the analysis of national, regional and local reports and strategies, the project Water2Adapt analysed both short and medium term water availability projections, and defined a "most likely" socio-economic scenario, in order to estimate future water demand patterns at basin scale level.

The results underline that there is common agreement in all case studies in relation to temperature increase. Changes in precipitation are more uncertain, although Ebro and Po river basin agree on predicting an average decrease of water availability, particularly in warm seasons. Water demand for agriculture uses is foreseen to increase, both in the Italian and in the Spanish case study, while the agriculture sector demand estimation in the German case study is characterized by lower confidence, because of high uncertainty in precipitation patterns. All case studies agree about unchanged future industrial water demand, while the estimation on future domestic total water demand is variable among the case studies. Because of growing population, total domestic demand will increase in the Po case study. The Spanish case study is characterized by higher uncertainty, while the total domestic demand of the Weser river basin could possibly decrease, because of decreasing total population in the basin.

6.2 Insights from the Ebro river basin of the Basque Autonomous Country (ES)

At the scale of the Basque Autonomous Country, the expected future climate changes have been studied in the K-EGOKITZEN project. The tendency goes towards a decrease in precipitation and increase of extreme temperature. When estimating climate changes at local scale, the sources of uncertainties become important. We have therefore retained the tendency of the changes instead of precise figures. It is expected in the next century that **extreme temperature** would increase: warmer minimum temperature in winter and warmer maximum temperature in summer. The amount of **annual precipitation** is expected to decrease more especially during summer.

The reduction of precipitation would reduce the water available as well as modify the flow of rivers.

The modification of the demand is the other component of analysis for the equilibrium of the water system. The demand is affected by socio-economic changes, demographic and in uncertain proportion by climate change itself.

The Basque Institute of Statistics has estimated scenarios of demographic evolution in the Basque Autonomous Country. Following these scenarios and a constant per capita demand, we estimate that the **domestic demand** supplied by the Zadorra system would vary from 35 million m^3 to 70 million m^3 per year by 2050. The current demand is around 56 million m^3 A spatial analysis of the change also reveals that the variations in Vitoria-Gasteiz would be greater than in Gran Bilbao. Moreover, the temporal evolution of these changes reveals that in almost all scenarios the major changes would occur between 2025 and 2050 which gives time to design appropriate adaptation measures (W2A2012b).

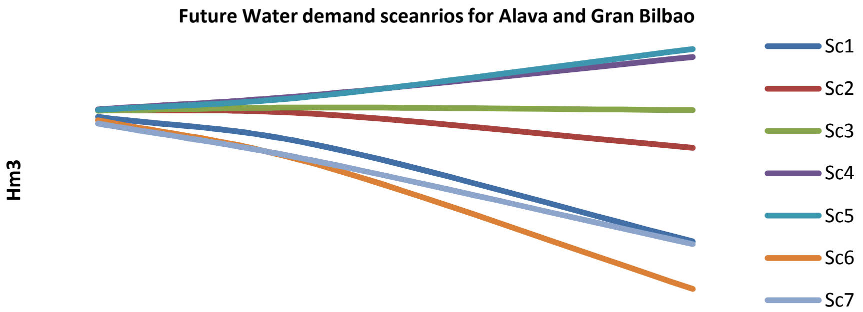


Figure 9: The future expected residential water demand. Source: own elaboration

The potential future water demand in agriculture has been analysed by the Basque Water Agency (URA 2010). The model of prediction is based on the comparison of the current capacity of irrigation (dark green in figure 8) in Alava and the potential capacity of irrigation (light green in figure 8).

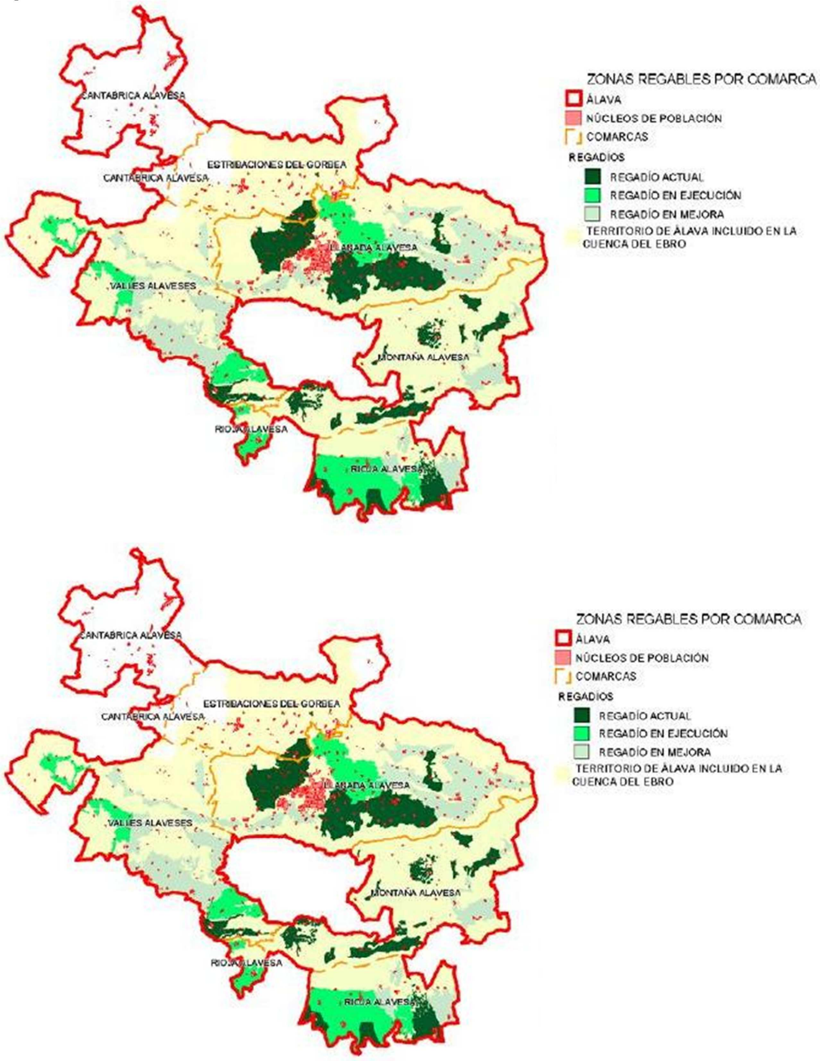


Figure 10: Future and current agricultural water demand in Alava. Source: URA 2010

The current irrigated area in Alava is 8204,3 Ha, and the estimated consumption is 27.56 million m^3 or 3,359 m^3/ha on irrigated land and 1,285 m^3/ha on irrigable lands.

The potential of irrigable lands is 60,132 ha in Alava. Based on a unit consumption of water of 1,092 m^3/ha the potential future water demand is about 65.65 million m^3. The unit consumption of water has been estimated as 85 per cent of current consumption on irrigable lands according to the evolution of the vineyards and other irrigated (URA 2010).

The future water demand for the industrial sector is based on the assumption that the own pumping remains constant (as well as the transfers) and on the full occupation of industrial areas planed on land uses planning. It would result in a demand 15 per cent larger than the current demand.

Hydrological units	Urban industrial demand	Transferred demand (CABB)	Own pumping	Total
Arakil	0,58	0,00	0,02	0,59
Baia	0,35	0,00	0,16	0,51,
Ebro	1,01	0,00	1,42	2,43
Ega	0,16	0,00	0,00	0,16
Inglares	0,02	0,00	0,01	0,03
Omecillo	0,03	0,00	0,00	0,03
Zadorra	5,95	0,00	4,41	10,37
Total Ebro of the BAC	8,10	0,00	6,02	14,13
Total BAC	35,13	12,08	58,02	105,29

Table 6: Future industrial water demand in Alava in hm3/year. Source: URA 2008

The distribution of the future of water demand would remain relatively unchanged over the territory: the Zadorra unit is always the basin of attraction of the industrial activity around the city of Vitoria-Gasteiz.

These estimations are based on the scenarios of evolution of the demand independently of climate change considerations and adaptation of the sector to climate change. Such climate change based scenarios are more complex and need more sophisticated models that account for the adaptation by the considered entities to climate change, i.e. land use changes in agriculture, technological changes in industries are some examples of the non-public adaptation measures that would need to be considered and known by social sciences with acceptable degree of uncertainty.

6.3 Insights from the Po river basin (IT)

Climate and land use changes substantially affect water security in the basin. The IPCC 4th Assessment Report (AR4) includes the Po valley among the European continental zones affected by a shift of rainfall regime and amplified extreme events (Naldi et al., 2008). The future changes in precipitation in the area are less clear. All models show a northward shift of the rain bands but the Po river basin is located in the transition zone that is rife with substantial uncertainties. It is expected though that increased temperature will strongly influence the liquid/solid precipitation ratio and the underlying retention effects in the water runoff. According to Coppola and Giorgi (2010) climate change signal over Italy varies seasonally, with maximum warming in summer and minimum in winter season. According to the models precipitation will decrease substantially in summer and will increase slightly in winter. Seasonal temperature anomaly probability functions (PDF's) highlight a shift to higher temperature coupled with a flattering and broadening both in temperature and precipitation patterns, especially in summer. This implies increased extreme climate events, such as very dry seasons and extremely hot seasons (Coppola and Giorgi, 2010). Other studies from Im et al. (2010) about the local effects of climate change over the Alps, shows a consequent effect of temperature increase, with decreasing snow cover, evapotranspiration increase and decreasing soil moisture in spring and summer. The models developed by Im et al. (2010), suggest an earlier peak snowmelt season, which coupled with lower snow accumulation, reduces the water retention capacity of the basin. This fact increases water insecurity to warmer summers. Concerning the trends of river water discharge observations, the Euro-Mediterranean Centre for Climate Change (CMCC) analysed river discharge extremes of the Po river. Conclusions suggested that the test performed on minimum and maximum discharge with a confidence level of 5 per cent, show that the series are homogeneous only within the period 2023-2002 (Vezzoli, 2012) for minimum discharge. In the last decade the study identified a sharpening in minimal discharge, which is the only signal of climate change in the dataset, but it also highlighted that the issue needs further investigation, because the period 2003-2008 recorded two of the most severe droughts (in 2003 and 2006-7) ever occurred in the Po river, which could undermine the statistical trend. According to this study river flow discharge are quite uncertain. Climate change effects have also been investigated by ARPA Emilia Romagna (ARPA-ER), which focused on the water budget of its region. Even if the results are characterized by high degree of uncertainty, it is worth to report that ARPA-ER recorded that Emilia Romagna mean temperature increased by about 2°C (~ 0.5°C/10y) over the past forty years (Cacciamani et al. 2010a) and precipitation decreased by some 20 per cent (Cacciamani et al. 2008). ARPA-ER reported that the intensity of single rainfall events increased whereas the number of the rainfall events decreased. With almost 50 per cent decrease from the previous long-term average, the decline in average precipitation is particularly pronounced in spring and summer periods. Snow cover and volume of glaciers show similar trends, as a consequence of shorter snow accumulation seasons. Cacciamani et al. (2010b) stated that the precipitation drop started in the early '80s. The difference in mean rainfall quantities in the last 25 years is estimated to be about 100 mm. It is a noticeable measure, corresponding to 10 per cent of the mean annual rain in Emilia Romagna. However, these conclusions disagree with the analysis complied by CNR (Nanni et al. 2007). This research focus on secular time series measured in 100 Italian stations. The decrease in precipitation is still visible, but it is defined as "minor and statistically little significant". Concluding, the uncertainty about climate scenarios for the Po River Basin is still great. Although several studies have reported changing trends in precipitation and river discharge, the issue requires further investigation to confirm a specific trend. Due to the geographical position of Po River basin in the climate change transition zone North-South and due to its orographic characteristics, influenced by the Alps, the future climate scenario is still extremely uncertain. However, based on CMCC (Gualdi, 2012) estimations, a climate change seasonal baseline scenario, could be defined as follows: 1) Lower precipitation in all seasons, except for Winter; 2) Higher temperature in all seasons; 3) Higher evapotranspiration in all seasons.

Concerning water uses, this study defined a "most likely " socio-economic scenario, which is used to estimate the water balance of the basin. The scenario considers all sectors, from civil supply to agriculture and industry. The first analysis concerns the "Demographic Development scenario" (ISTAT, 2011). The Northern part of Italy, which for the most part is covered by the Po river basin, will see a moderate demographic grow, around 10 per cent but a quite consistent transformation of its social distribution, which foreseen a shift of the socio-demographic fabric towards aged and non-Italian resident population. It is estimated that these factors could induce new water demand patterns of domestic consumption. In relation to the industry water demand, it could be considered that the industry production delocalization process is now stable. Therefore there is no addition water demand foreseen for the industry sector in the basin. According to the new National Energy Strategy, currently under development, the sector will not change drastically in the next future. The renewable production trend will further increase, with a specific focus on biomasses, which could indirectly, through the agriculture sector, induce additional water demand. However, based on report, the industry sector water demand could be considered stable in the medium-long term. Agriculture is instead another matter. Sector water demand trends are of extremely difficult interpretation. European Policies, such as the Resource Efficiency Flagship of the EU 2020 Strategy calls upon Member States to increase irrigation efficiency. Rural development funds, the new European CAP 2014-2020 and the National Irrigation plan include consistent efforts for enhancing irrigation efficiency. However ss highlighted by ISTAT in the recently issued Sixth National Agriculture Census (ISTAT, 2011a), the sector faces long lasting contraction.

Therefore based on this assumption the "most likely" scenario developed in this study for the Po river basin foreseen: 1) Industry and energy production sector's water demand will not see any consistent change in the medium-long term. The new National Energy Strategy does not change significantly the Italian energy mix. Even though renewable energy will increase, water demand change for energy production will be marginal; 2) Domestic water demand will most probably show a slightly increase due to socio-demographic changes in the short-medium term. In the long term the tendency is stable or even decreasing because of the implementation of water losses reduction measures, building efficiency and conservation promotion; 3) Water demand for agriculture production shows opposing trends. Irrigation efficiency will optimized the system, inducing possibly additional production. Increasing trends in temperature and evapotranspiration will further raise water demand for food production. Increasing biomass production for energy purposes will augment the stress on water resources during drought seasons. Diffusion of water resilient crops will further decrease the water demand of sector; 3) Water availability within the Po river basin will be no longer abundant and easily accessible. Reduced snowing precipitations and glacier melting will affect the river discharge patterns influencing the seasonal water cycle. Uncertainty in future river water discharge is still great. Saline intrusion will further worsen the fragile condition of Po river delta; 4) Climate change will further increase meteo-climatic inter-annual variability. Extreme climate events, such as very dry seasons and extremely hot periods will affect more frequently the area.

6.4 Insights from the Weser river basin (DE)

Future water use depends significantly on demographic development in Germany. According the estimates of the Federal Statistical Office, population in Germany will decrease from the current level of 82 million in 2011 to 65 million (i.e., current population minus 17 million) by 2060, representing a reduction of 20 per cent (Federal Statistical Office, 2010). Furthermore, every third person will be older than 65 years (Bundesministerium des Innern, 2012). Because of this demographic trend, total water demand is expected to decline in same order of magnitude (20 per cent), in addition technological improvements in water use efficiency will likely further reduce water demand. According to studies in 2007 about 128 litres of drinking water per person per day were used for domestic and commercial use in Lower Saxony. In comparison with the rest of Germany, water demand in Lower Saxony was about six litres higher in 2007 and is consistently higher, reflecting a lower price of Euro 1.19 per m^3, about Euro 0.40 cheaper than the German average (LSKN, 2009). However, water demand per capita has steadily decreased in Lower Saxony consistent with the rest of Germany.

The influence of demographic developments on water demand in Lower Saxony is based on the prognosis of the German Federal Statistical Office. It is projected that population in the federal state of Lower Saxony of which the Weser basin is a part, will decrease from 7.9 million in 2010 to between 6.6 and 7 million residents in 2050 (Federal Statistical Office, 2010). It is therefore assumed that there will be a corresponding decrease in water demand (KLIFF Research Association).

As consequence of this reduced water demand it is anticipated that there will be problems in maintaining high standards of drinking water hygiene as a result of reduced flows of water through the system. Existing water infrastructure has been designed for higher volumes of water use. This dilemma is described in the section below, "Future trends in water availability in urban area".

Another aspect of water use which is growing in importance is **"virtual water"** use. While water-saving techniques and changing consumer behaviour has reduced per capita water use to less than 130 litres per day in Germany, virtual water demand has increased. According to a study of the World Wildlife Fund (WWF, 2009) determined that although direct water consumption per capita has steadily decreased, every German has a daily water footprint of 5,288 litres with about half of the German demand for water is imported through foreign products (Table 3). Similarly this applies to resources and products exported from the Weser Basin to other regions and countries and from Germany as a whole. One could take issue with the calculation behind and therefore the accuracy of these figures for virtual water consumption, but the message remains that we grossly underestimate the volume of water consumed at every scale level especially in industrialised countries. The concept of virtual water needs to be taken into account when considering water demand management as a measure for drought and water scarcity.

	Internal Water Sources	**Imported Water**	**Total (km³/year)**	**Percentage of Total Water Use**
Agriculture	55.7	61.9	117.6	73.,7 per cent
Industrial production	18.84	17.56	36.4	22.8 per cent
Households	5.5	-	5.5	3.4 per cent
Total (km³/year)	80.0	79.5	159.5	100 per cent
Per cent of total	50 per cent	50 per cent	100 per cent	

Table 7: Water Footprint Germany (Source: World Wildlife Fund, 2009)

About 55 per cent of the land area in the Weser Basin is designated for agricultural use. One of the expected impacts of climate change will be a negative climatic water balance in summer time (May-October) thus affecting water availability for plants during the growing season. Depending on the local soil conditions and climate, the need to irrigate will increase during the growing period in Lower Saxony.

The State Office for Mining, Energy and Resources (Landesamt für Bergbau, Energie und Rohstoffe, LBEG.) calculated the average irrigation water needed for agricultural plants in the period 1961-1990 and in the future period of 2011-2040, the latter under climate change conditions. Figure 9 displays irrigation water needed for crops during these periods in Lower Saxony. The Weser Basin covers approximately 57 per cent of the federal state's area.

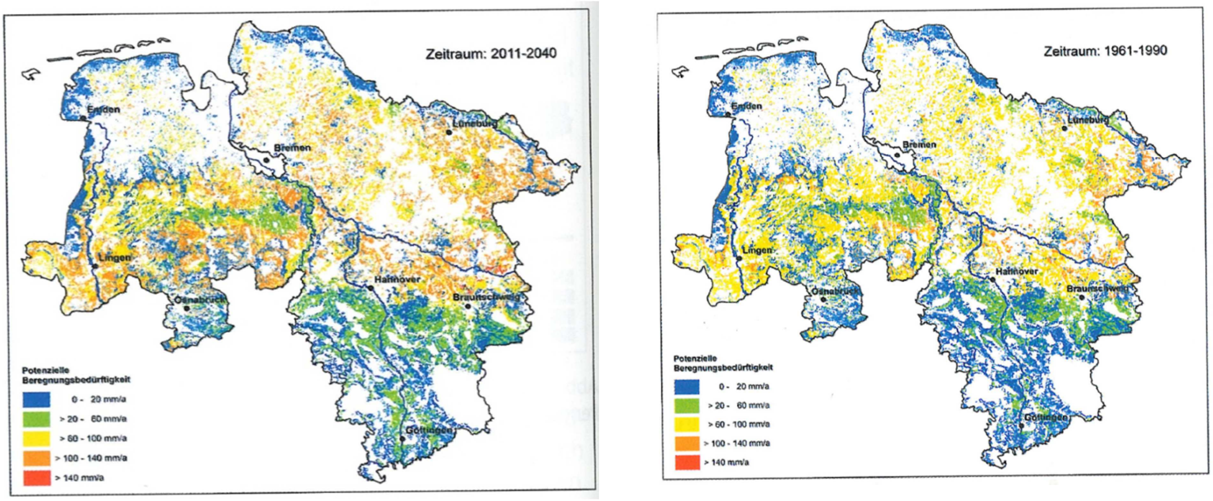


Figure 11: Past and potential irrigation water (mm/a) needs for crops in Lower Saxony for the periods 1961-1990, left and 2011-2040, right (Heidt and Mueller, 2012).

The average demand for irrigation water is calculated by the additional quantity of water that is needed to supplement precipitation for the optimum water supply for root crops and grain or to maintain 40 per cent of water-holding capacity in the root zone (Heidt 2009). Plants in southern Lower Saxony will be less dependent on irrigation water because of the good soil conditions, in contrast to the north-east, where irrigation water needs range from 75 mm to 150 mm.

In summary, irrigation in the Weser Basin will increase over the next 30 years. However, climate projections contain uncertainties, especially the comparison of actual and simulated precipitation levels lack precision. Therefore a concrete prognosis of the required quantity of irrigation water for crops is currently not available (Niedersachsen Ministerium für Umwelt, Energie und Klimaschutz, 2012b).

According to several literature sources and experts, for example, the public utility of Hanover, the potential for further water savings in the residential sector of the city of Hanover appears to be exhausted. Rather, the reduction of drinking water use as a result of water-savings programmes and decreasing population have caused or have the potential to contribute to several problems.

In the 1970's various scenarios predicted a continual rise in water demand per person in the former West Germany. The water use in the year 2000 was predicted to be between 193 and 219 litres per person per day. According to the statistics of German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft – BDEW), public water use fell approximately 40 per cent below the predicted value (BDEW, 2011) and in 2009 had dropped by 17 per cent from the 1990 level of 147 litres per person per day to 122 litres. This decrease in water use in the last two decades years has had far-reaching consequences for the water infrastructure and consequently for the water quality. The low flow rate and lower levels in the municipal sewage water networks cause depositions in the oversized sewage pipes, resulting in biogenic sulfide corrosion of concrete pipelines and at the very least an offensive odour. Within the water supply system, there is also a risk of contamination of drinking water as a result of reduced flows – specifically as a result of stagnant water (Koziol, 2007).

Water systems in urban areas are especially vulnerable, where the water supply infrastructure is designed to have sufficient capacity also for fire-fighting. Although water saving is good for the environment, a decrease in water use will also have negative impacts that could counteract this positive effect, e.g., the requirement for increased flushing of piping systems to avoid depositions in the pipes or to ensure the quality of drinking water. Under these circumstances, the cost of maintaining water infrastructure increases significantly and the consequences are increasing water prices (Koziol 2007). The result of this water saving in response to increasing prices and reduced use due to demographic change, is ultimately, a vicious circle: the consumer reduces water use due to increasing costs, but the costs for maintaining the infrastructure increase because flows through the system are too low, given the capacity of water supply and wastewater pipes (Werner, 2011).

7 Proposed WDM policies

7.1 Synthesis

After analysing the effects of water scarcity and drought on the socio-economic system (chapter 3 and 4), the ex-post revision of drought risk mitigation measures in place (chapter 5), and the future trends in water availability and uses (chapter 6), this chapter proposes practical recommendation of water demand management for each analysed river basin district. The recommendations are mainly divided into three topics: water efficiency, economic policy instruments, and public awareness and participation.

An increased *water efficiency* has been called by both the Communication of the European Commission (COM (2007) 414 final) and, more recently, by the Blueprint for Safeguard Europe's Water resources (COM (2012) 673). Efficient water use is also the foundation of the EU Resource Efficiency Flagship initiative as a part of the Europe 2020 Strategy. Improved efficiency of water allocation and uses and better planning for drought spells, likely to be amplified by climate change throughout Europe are accepted as the most effective ways of adapting to climate variability and change. All case studies have analysed possible implementation of improved efficiency strategies at RBD scale, in the civil supply sector, in agriculture and in energy production. Efficient water governance has also been identified has crucial for enhancing appropriate risk mitigation measures.

Economic Policy Instruments (EPIs) represent incentives aimed at changing individual decisions and behaviour in line with the collectively agreed goals of water policy in the European Union (EPI-Water, 2011). EPIs have proven to stimulating efficient water allocation; generate revenues to sustain and improve water provision (i.e. recover cost); foster water conservation; and promote technological innovation. However, not all these objectives are not satisfied to the same extent (Xerochore, 2009). Efficient allocation of water require that the prices reflect marginal costs of water provision. Ideally, externalities such as environmental and social costs should be included in the calculation of marginal cost of water provision. However, in practice, accounting for all the externalities can be cumbersome and expensive, since they are numerous, variable in time and space, and often hard to measure (PRI, 2004). The main EPIs for sustainable water management which have been considered include water pricing, trading, cooperation instruments and risk transfer.

7.2 Insights from the Ebro river basin of the Basque Autonomous Country (ES)

The expected climate change and evolution of the water demand (section 6) are a basis to avoid maladaptive policy responses to changes, i.e. policy responses that would increase the vulnerability instead of decreasing it. Accounting for the intrinsic or knowledge based uncertainties would mean to improve research, propose flexible measures and control for the possible adverse or rebound effects of some measures.

In this context, we have focused our analysis of the policy measures that could be implemented, improved or tested to answer to the adaptation problem and maintain the system in a desired equilibrium.

We give a particular emphasis to the instruments that improve efficiencies. The *allocation efficiency* deals with the capacity of society to allocate limited resources between competing sectors in order to maximize the general welfare. *The technical efficiency* focuses more directly on how water is consumed; it indicates the quantity of resource needed for a specified objective.

In the water supply side, a significant volume of "uncontrolled" water has been identified in the Basque Autonomous Country. Therefore important improvement of the metering system, repair of leaks in the network and monitoring would contribute to use water more efficiently. In the demand side, the educational and information programs supported by the water utilities and irrigation association to adopt more efficient equipment are also instrument to develop.

But perverse effects of such gains exist. Consuming more efficiently water reduces the bill and the revenue saved could be allocated to other water consumptive uses, for example more water demanding land uses, expansion of irrigation areas, new equipment for households, industries, farmers or municipalities.

The analysis of the water tariff structure in the two water utilities of Bilbao and Vitoria-Gasteiz that use the Zadorra reservoirs revealed important lessons in terms of the cost recovery principle (W2A 2012f, W2A 2012g). The study of the bill structure revealed that the water utilities are firstly concerned by the recovery of the cost, then by efficiency and equity. The fixed part of the tariff is then much more important than the volumetric part, on average two third of the bill but up to 80 per cent. Therefore if the engagement in the recovery of cost principle is not questionable to maintain the system in a sustainable exploitation, then increasing the volumetric part in the bill would reduce the demand, in the proportion of its elasticity. To do so, increasing the volumetric price is an option or reducing the cost of functioning is another option that could be studied.

In the agricultural sector, the public supports in the water system are important. Farmers regrouped in irrigation association receive a quota of water in exchange of the entry fee. The possibility to implement adequate water tariffs should be studied in order to allocate efficiently water and reduce public supports. This would imply a monitoring system with systematic adoption of metering systems.

The Zadorra system is a multiple users reservoir. The current system of water allocation depends on the warranty curves that define a frontier of uses between the energy company and the water utilities. Above this curve the energy can produce without external restrictions, below the water is reserved to the water utilities. In a climate change context, these curves would need to be updated to account for a different variability in the water availability and a new variability in the demand. An instrument that should be considered to improve the allocation efficiency in a climate change context is the establishment of a water market in the Zadorra. This market would have to be regulated given that it is an oligopolistic market. Investigation to test whether a local water market would be Pareto-efficient should be regarded with interest.

The water system is characterized with high fixed costs and increasing returns to scale. Therefore, a large number of customers are required to receive returns from the initial investment. Therefore, the structure of the water supply market goes naturally to a monopolistic or oligopolistic structure.

In the province of Alava in the Ebro river basin the Basque Autonomous Country, it has been observed the larger number of water utilities or municipalities that supply the services compared to the rest of the BAC. These entities face the financial risk of not being able to recover costs with tariffs in case of large repairs or investments in the network (new reservoir, repairs of uncontrolled, sewer systems, etc.). The possibility of regrouping should be studied carefully in this province.

The public support for maintenance costs helped to maintain the water system but such a support is only a transfer of deficit from one sector to another. The role of the public sector should therefore be questioned in this sector.

7.3 Insights from Po river basin (IT)

The research conducted within the Po RBD case study has contributed to drafting the Italian Strategy for Climate Adaptation. It highlighted the growing 'thirst' of the key water-intensive sectors, and the vulnerability to intense drought spells such as those experienced in the 2000s, or worse, in the 1990s. The research pinpointed *water demand management* policies, able to reduce the water consumption/demand n short and medium term.

Governance Reform and coordination at RBD scale

Arguably, the long-winded implementation of water governance reform in Italy has undermined the efficiency and effectiveness of institutional responses to drought. The Po RBD Authority, envisaged in the law 152 has not yet been effectively put in place and the development of the River Basin District Management plan has been assigned to river basin authority formally abolished in 2006. The national regulatory agency for water supply and sanitation (WSS) was repealed and the competences only recently transferred to the National Authority for Energy and Gas. The authorities of the Optimal Territorial Areas (ATO), the territorial unit within which the WSS is optimised, too have been abolished and are being replaced by other territorial bodies.

The abrogative referendum held on the 13th of June 2011, which abolished the enumeration of own capital as an eligible cost component and the mandatory privatisation of water service provision. The lack of Government's immediate response to the result of the referendum has caused regulatory uncertainty and hampered the badly-needed investment in water infrastructures.

Presently it seems difficult to overpass local interests and adopt an integrated approach for the management of the water cycle. The new 'district' approach introduced by D.Lgs 152/2006 received strong opposition. In fact, the division of the territory into districts and the creation of an appointed authority raised several issues. It is a fact that the former basin authority received more responsibilities and functions compared to its operative and financial capacity. Moreover the absence of a clear enforcement instruments combined with the necessity to define a large framework of competences is producing a serious deficit in the implementation process of the reform (Alberton, Domorenok 2011).

The water balance is essential to design the sustainability of water resource management actions. Water abstraction entitlements are insufficiently coordinated at RBD scale, they are not clearly defined and most of the time expired or based on centuries-old rights. In addition to this, water abstraction entitlements are competence of the Regions, sometimes delegated to the provinces, whereas the RBD Authority has only a minor role. Moreover the monitoring of quantity and quality of water in the basin is provided by regional authorities, which do not share a common platform for sharing the data. With consideration to this limits and to the importance of the actual and future budget for planning purposes, it is strongly suggested that any large abstraction should be subject to environmental impact assessment, prepared and coordinated by the RBD Authority. Furthermore it is highly recommended the creation of a common data platform, under the supervision of RBD Authority, for the collection, validation, achievement, and elaboration of hydro-climatic data. Modelling of future water budget should include the effects of climate change and socio-economic scenarios, which shall possible be developed at River Basin scale by national statistical institutions (e.g. ISTAT).

Water supply service

The civil water supply offers a wide range of opportunities for a more efficient use of water. These include improved water efficiency in buildings, water conveyance efficiency (quicker detection and reduction of losses), rain water harvesting and waste water re-use.

Water efficiency in buildings can be accomplished through the implementation of product and building level policies. *Product policies* for an efficient use of water in buildings include three instruments. Firstly, the *voluntary labelling*, whose objective is to inform the consumer about the water performance of a device, for instance, eco-labelling for taps and showerheads. The second product policy instrument is related to *mandatory labelling* for all water products similar to the energy-using products. The third product policy tackles *minimum water efficiency requirements* for water-using products that would be placed in the market in the future. Toilets and showerheads seem to be the water-using product to be addressed in priority, given their high shares in the residential (toilets and showerheads) and non-residential (toilets) water use patterns (EC, 2009). *Building-level policies* include four schemes which can allow the efficient use of water. Firstly, the *water performance rating/auditing* of buildings which be accomplished through the introduction of indicators or requirements that a building needs to satisfy, concerning water performance, and covering also other environmental issues. Another building-level policy scheme is the *minimum water performance* requirements of buildings whose objective is to set the standards under which a building is defined as efficient enough. *Certification scheme* for water reuse and harvesting, collection and reuse of greywater, and collection of water from roofs is another policy that could be further pursued and lead to significant water savings. Empirical evidence for the implementation of rainwater harvesting approaches in France and UK showed that water savings can reach up to 80 and 50 per cent respectively (Ecologic, 2007).

Another policy which can lead to significant water savings is the improvement in the efficiency of water distribution network. The adoption of water smart metering for detecting water leakages and provide detailed information about water consumption for water utilities and customers (daily and interval collection data e.g. every 12 or 24 hours) may half the losses.

Agriculture sector

A better water efficiency in agriculture can be achieved through improved irrigation infrastructure/technology and application efficiency, including a change in practices for instance from surface irrigation to sprinkler or drip irrigation with estimated water savings to 15 per cent to 30 per cent, respectively. Substantial potential water savings can also be achieved by the change of crop patterns and the use of more drought resistant crops. For instance, the switch from high water demanding crops, like maize, to low water demanding crops reduced the vulnerability to droughts. Furthermore, the implementation of new technologies for the re-use of sewage effluent such as sand filtration or reverse osmosis could lead to significant water savings up to 10 per cent and 12 per cent (Ecologic, 2007).

Energy production sector

The 14 largest thermoelectric plants in the Po-RBD, accounting for ca. 75 per cent of thermoelectricity generated, withdraw substantial volume of water from the Po river or the main tributaries. The total volume withdrawn has been assessed to ca. 130-140 m3/s. The implementation of advanced cooling technology such as dry cooling, evaporative cooling and hybrid cooling can reduce the dependence of power plants from natural water resources and therefore, and can lead to reductions in water use and consumption, by up to 80 per cent (Central Electricity Authority, 2012). An economic analysis regarding the different costs of cooling systems showed that dry cooling systems can become profitable and thus can be justified economically if the cost of water is expensive and/or the cost of power is cheap (Ecologic, 2007). Other water savings measures that can be applied in the thermoelectric generation are the use of recycling of cooling water and improvement in energy efficiency of new thermoelectric plants. The former led to several projects in Latvia, Poland, Ukraine and Hungary with substantial impact in the reduction of water consumption.

Water tariff

The economic policy instruments such as water pricing operate within the boundaries limit laid down by the regulatory environment. In Italy, the eligible costs of the WSS services are determined by central government, leaving little leverage to the lower authorities. Controversial is the cost item referring to remuneration of invested capital (7 per cent according to the Normalised Method), abrogated by the 2011 public referendum, leaving space for different interpretations as for what is the role of private sector in the service provision. Empirical evidence shows that water pricing is a suitable tool for encouraging water conservation and demand management. Water is a social good whose service provision can be governed by economic instruments. The recognition of right to water as a fundamental human right is not at odds with the participation of private sector in the water service provision. The access and affordability of water can be reconciled with water pricing in several ways. In Region Emilia Romagna (RER), it is managed by social tariffs whose costs are distributed among the wealthier consumers. Alternatively, it could be managed either by income support (connected or not to water consumption), or by facilitated payments. The performance factor PCn introduced in RER is an effective instrument to improve the quality of water distribution service and reduce water leakage.

However, the tariff system has not guaranteed necessary investments into extension and modernisation of water infrastructures. The planned investments in water infrastructure are by far too low in order to guarantee a sustainable and reliable water services. The failed attempt to reinforce participation of public sector in WSS provision introduced a regulatory uncertainty discouraging from further investments. The water utilities will have access to external sources of finance, such as loans, only if a sufficient and reliable stream of revenue is ensured

Water transfer and trading

Water trading is also another effective instrument for water demand management. Water is not equally distributed in the geographical space. With the technological and engineering development, the possibilities to build more and more efficient water infrastructures permitted to create complex schemes to convey water from a river basin to another. This practice is called inter-basin water transfer or trans-basin diversion. Different could be the benefits of the water transfers but enormous could be the negative side effects of the practice under consideration. However, inter-basin and intra-basin water transfer from different catchment areas could be the most effective and efficient measure to deal with water scarcity in water scarce regions. An example of an inter-basin water transfer at the Italian regional level is the water pipeline from Basilicata and bordering regions to Puglia in Southern Italy (A.d.B 2009). The water transferred from the mountainous regions to the plains of Puglia is fully integrated into the public water supply, thus serving all parts of society and economy such as households, tourism, industrial production, and agriculture (AQP 2009, Xerochore 2009).

In the case of the Po river Basin, the transfer can be an effective solution to cope with the structural water scarcity in dry periods in the Romagna region. Especially regarding the city of Rimini, drought events impacted in several occasions the water security of Rimini urban area. The agricultural sector in the Po plain, especially in the Piedmont and Lombardy area is responsible for large part of the water abstraction in the basin. The irrigation in the area has not always been characterised by the highest technology in terms of efficiency. The Emiliano Romagnolo Canal (CER) is the infrastructure that could be used to better and more efficiently distribute the water resources among and outside the Po river basin. The strategy could be developed in order to ensure water supply and security to the urban areas of the Romagna region utilising part of the resources saved through the improvement of the efficiency in the upstream agricultural area of Piedmont and Lombardy. The economic sustainability of the measure can be ensured by the monetary compensation offered by the beneficiary municipalities, which will pay a service. The economic flow could be also utilised for the implementation of the infrastructural investments in the upstream areas.

Concluding, water trading is a policy which could be further investigated in the Po river basin for applicability against increasing water scarcity conditions. The structure of water abstraction rights in the basin is extremely complicated. Very often water right are based on historical motivations, licences for abstraction are renewed automatically and rights are not explicitly formalized. Agriculture is the sector using 80 per cent of available freshwater. In the sector water in managed by Land Reclamation Boards which water rights were established in the past, when climate change was not exhibiting its effects yet. Even if surrounded by uncertainty, current meteo-climatic changes show an evident trend, which require innovative and original solution. Even though water markets at the moment have no possibility to be implement at basin scale, future and periodically monetary compensations could still be investigated for application against increasing water scarcity conditions. For example the water transfer from upstream Lombardy and Piedmont, could be compensated from downstream, out-basin Municipality area of Rimini, when needed. Moreover the existence of a water trading scheme, could be effective in compensating the voluntary inter-sector water transfer, which is often required during drought periods, such as the one implemented in 2003 during the Protocol on Intent.

European Environmental Agency (EEA, 2010) stated that the objective for the next five years is the systematic co-operation between urban water managers and other professionals and the local communities to redesign water management systems which can be integrated with other city services in order to deliver sustainable water services and simultaneously, to enhance life both within and beyond the urban environment. The exploitation of all sources within a city and their integration in the urban water cycle is of great importance in mitigating climate change shocks. In this context, international experience can be useful like the development of Water Sensitive Urban Design (WSUD) in Melbourne (Australia). WSUD is associated with the integration of stormwater, groundwater supply and wastewater management at the development scale and the protection of aquatic ecosystems (Elmer, 2010). WSUD has recently been adapted and implemented with success in other countries like in the city of Hamburg (Germany) Therefore WSUD can be used as a tool by water managers and the local communities for ordinary planning, which could enhance urban resilience climate change adaptation processes. Consultation with stakeholders in Ferrara and Parma, have been useful in identifying weakness and gaps. For example during the workshops it was highlighted that network efficiency is of great significance to cope with water crisis situations and meet future water demands as well. Investments in maintenance of infrastructure like the reduction in losses from abstraction, treatment and distribution of water and in protecting the existing water resources from pollution, are necessary. Research on finding alternative water sources in order to reduce the dependence of only one source, surface or groundwater, needs to be further pursued. For instance, in Ferrara 76 per cent of total potable water comes from rivers and 24 per cent from groundwater. The opposite case exists in Parma where the major source of water comes from groundwater. The construction of floating drafts in the rivers to ensure sufficient water supply, in the case of Ferrara or the diversion of water from other rivers, in the case of Parma, are considered as examples of prevention measures to reduce vulnerability of cities in extreme events. Except for management interventions, public awareness via education and information campaigns for the efficient use of water needs to be further pursued. It was finally concluded that rigorous actions towards a more water sensitive behaviour and management, such as the WSUD approach, should be taken not only during and in aftermath of emergencies, but also as a risk prevention and preparation measures to extreme events, even in otherwise water-abundant regions.

7.4 Insights from the Weser river basin (DE)

Education and knowledge is the simplest and often most cost-effective way to support the farm level measures. This can be achieved by improving education and training programmes for farmers and strengthening consultation opportunities. This already happens through agricultural advisory services and associations in Lower Saxony and the rest of Germany. The interviews with 21 farmers in the district of Heidekreis illustrated that farmers are well connected and improve their skills through by reading relevant publications, training and informational workshops, as well as by simply exchanging with colleagues. Nevertheless the results also pointed to a lack of knowledge of agricultural economics, because globalisation makes farmers more dependent on, and vulnerable to fluctuations in the world market prices (for example, concerning the purchase of fertilizer and seed, and the selling of their products). Consequently the application of good agricultural techniques are the basis for successful farming but a decent understanding of economic conditions will become more important. Through education and training, the knowledge of climate adaptation techniques can also be shared.

Another way to increase the motivation of farmers to adapt to water scarcity is through financial incentives. Until now financial support for farm development or expansion does not address climate change conditions. This aid could be easily expanded to incorporate adaptation to climate change, with reference to both water and energy efficiency.

Irrigation water that will be required under future climatic conditions could to some extent be offset by the implementation of various water management measures. If measures are linked to technical innovations and support, farmers are often willing to invest individually or to organize themselves in an association to invest together in new techniques, especially because the introduction of these technologies can be costly. It is more difficult to remove bureaucratic rules that restrict such technological innovation. Farmers invest if the administrative structures and water allowances work in their favour.

Regional measures could be implemented to recharge the groundwater body, for example by using ditches or drainages, which can be redirected. Then precipitation is forced to drain into the ground and cannot flow fast out of the area during the winter time and it could be used for irrigation in the vegetation period. Another possibility to recharge the groundwater body is to substitute the groundwater by process water or construct seepage reservoirs. Replacing groundwater with septage water for irrigation is not easy to implement because of water quality issues and lack of public acceptance. Research and promotion campaigns could influence consumers attitudes and make available new sources of irrigation water. Mediterranean countries as well as Northern European countries could look to countries such as Israel, that have a well-established system of greywater separation for use as irrigation water.

One institutional instrument to control the use of irrigation water in the agricultural sector are water allowances given to farmers for a specific period. The prolongation of water extraction allowances could secure water availability in agriculture. A sliding mean of seven years could be expanded to ten years, so farmers have more flexibility in responding to consecutive droughts. On the other hand exceeding the limitation of water abstraction should be more strictly controlled with higher fines.

Another measure to secure farm income in the face of climate changes could be insurance. Farmers can insure their crops and their income against hail, storms, heavy rainfall, frost, drought and flood events. However, insurance can be quite expensive. Furthermore this only applies to farmers not located in danger/risk areas (i.e., those areas that are often or regularly affected by natural disasters, like floods). The cost of insurance depends on various factors, like crop sort, location and productive system . In Germany every insurance type has a different rate depending on these factors including the insurance coverage and insurance premium.

In Germany many associations exist with diverse purposes related in some way to agriculture, such as dyke associations, water and soil associations and irrigation boards. All these associations represent the interests of, and are funded by their members (n.b. this membership can be obligatory) and the federal state. A new type of association addressing the needs of a region and its natural resources could present an opportunity to concentrate diverse interests in one public body. This association should be comprised of members of various branches such as nature protection, agriculture, forestry, water boards, soil and water associations and so on. With such an association, bureaucracy could be minimized and dialogue among diverse interests is supported.

Until now, the impact of water abstraction of surface and groundwater is not fully known. Calculations of drinking water abstraction areas are often estimated due to the complexity of hydro-geological systems. In order to determine more accurately the appropriate level of water extraction for irrigation a broader data set is necessary. It would then be possible to evaluate the infiltration rate of water through a seepage reservoir, and the effects of regional measures can be better quantified. In this way, a better assessment of abstraction limits of irrigation water can be made. However, in the case of groundwater on which most of the basin depends, increased infiltration is not an indicator of availability unless there are measures in place to increase groundwater retention.

In future the climate change should be stronger enforcement of the implementation of the Federal Spatial Planning Act (ROG, 2008) in which it is stated that climate protection must be taken into account in measures for mitigation and adaptation to climate change (§2, 6 ROG). Furthermore could it be useful to define "priority areas for agriculture" in the regional planning, then it could be possible to protect valuable farmland against other priority areas or civil works.

Economic and financial instruments, together with technological advances in water-saving infrastructure and techniques, and public awareness remain the most common and effective means of reducing water use. As discussed earlier, it appears now that the effectiveness of additional approaches are reaching the end of usefulness in reducing domestic water consumption.

One measure that will significantly help to reduce the maintenance costs and also drinking water use, is the separation of drinking water infrastructure from infrastructure for water designated for fire-fighting, making both pipelines smaller and therefore adapted to the capacity needed. This policy has already been implemented in the planning of new subdivision developments in some municipalities.

Furthermore, also within the context of spatial planning, it is possible to increase urban cooling by increasing urban green space and vegetation especially on roofs and facades, and by planting more trees. This measure has the additional benefit of increasing rainwater retention areas in urban centres and reducing the volume of stormwater requiring treatment. The City of Hanover has several sets of guidelines that support this measure. In May 2012 the City of Hanover published a report on Adaptation Strategies for Climate Change (Stadt Hannover, 2012). While the focus of this document is on the effects of thermal stress on the urban population, and on protecting water quality, the city takes an integrated approach in the proposing measures it proposes which address both drought/water scarcity and floods, in addition to heat waves.

The creation of **water retention areas and temporary buffers** together with the development of multiple use areas in urban centres (e.g. drainage and park areas) is also a relatively new approach that is being incorporated into urban (landscaping) plans. In addition, this measure has been promoted among home-owners with financial incentives in the form of reductions in wastewater charges. It is measure that more municipalities should adopt.

Another measure that has not been implemented on any large scale is the separation of **untreated water** for use as irrigation water and industrial cooling. The technology for separation, (partial) treatment, and (re)distribution, is available but not widely used in Germany, certainly not at an institutional level.

A sector of water use both within and outside urban areas that has been addressed in previous Water2Adapt reports for the Weser basin is **industrial water use** especially for cooling. There are studies and trials underway to improve techniques for more efficient use of water for cooling, including the reuse of cooling water, use of rainwater and cleaning technologies that save water and “closed cycles” (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2011). However, since the energy sector is most dependent on water for cooling, reduced energy consumption is another important way in which cooling water requirements can be reduced.

8 Discussion of the results

The Water2Adapt project, through the analysis of the economic and social costs inflicted by four drought events in three European Member States river basins (Ebro in Spain, Po in Italy and Weser in Germany), provided a critical revision of the risk mitigation measures in place against water scarcity and drought. The analysis of RBD-specific climate trends, and the elaboration of future socio-economic scenarios coupled with the consideration of future climatic scenarios, provided the current and future water account at river basin, which is in accordance with the first action called by the Water Blueprint (COM(2012)673) for appropriate river basin water management. Based on the outcomes of this investigation, the Water2Adapt Project provides suitable policies recommendations to each RBD, which shall be considered to reduce potential water stress, induce a more efficient use of water resources and enhance climate change adaptation.

Putting the right price on water is a priority of Southern Europe case studies, Italy and Spain, where water pricing has higher water saving potentials compared to the German case study, where on the other hand water demand per capita in the civil sector is at lower levels. The introduction of volumetric water prices in Italy and Spain for the agriculture sector could exploit additional water saving potentials and contribute the improvement of water flow monitoring, which has been identified as a major challenge for effective water accountability. Improvement in water storage infrastructure is a policy recommendation considered by both the German and Spanish case studies, while the Italian case study focused more on improving the governance at RBD level. The analysis has proven that Italy is facing an impressive challenge of water governance reform which contribute to undermine optimal water management efforts. Fostering water efficiency technologies and practices is identified by all case study as one of the policy options which RBDs' should implement. Water saving in buildings (Italy), waste water reuse and rainwater retention (Germany), reduced water leakage in both civil supply and agriculture (Italy and Spain), have all been identified for water efficiency enhancement. Innovative economic-policy instruments such as water transfer and water markets, are considered as possible solutions against increased water competition between sectors such as energy and agriculture. Even if the current situation still does not require an immediate application of such measures, the Spanish and Italian case study suggest the application of specific pilot projects in confined areas, in order to produce policy-relevant evidences for further development. Finally, all case studies have identified the necessity to include climate change scenarios in water management planning for appropriate water allocation.

Concluding, the Water2Adapt Project provides an additional contribution to the European debate about water scarcity and drought, defining concrete actions at RDBs' scale. Amongst other issues the Project success includes the following results: it delved into nuances of drought drivers and impacts; it characterised drought events; it evaluate droughts impacts and losses both economic and social; it provided ex-ante assessment of measures in place, institutional responses and governance; and finally it provided RBDs' specific recommendations for risk mitigation enhancement.

9 Partners' involvement

All partners contributed in equal way to the production of the research outputs, each solely responsible for own case study. A series of national and international workshops was held in Italy, Germany and Spain for foster stakeholder involvement and dissemination of the results. At the end of the project, in September 2012, the consortium organized the international conference "*Dialogue on water resources: from research to livelihood impacts*", in collaboration with the other Italian teams of the IWRM-NET funded projects *Icarus* (coordinated by the Euro-Mediterranean Center for Climate Change, CMCC) and *Water Cap And Trade* (implemented in Italy by the University of Bologna). Co-sponsored by the Italian Foreign Ministry and hosted in the prestigious Aula Baratto of the Ca' Foscari University of Venice, the conference attracted some 50 participants from Europe and Mediterranean region (see project website for more details and the proceedings).

Details about the activities in different case studies are listed below.

Ebro River Basin District case study activities

Activity	Purpose	Date
Interview of Cesar Samperio, water utility of Vitoria, AMVISA	Elicitation of local expert knowledge	*16 December 2010*
Interview of Luis Ganuza, irrigator association UAGA	Elicitation of local expert knowledge	*10 January 2011*
Interview of Gonzalo Cabo Isasi, Iñaki Arrate, Basque Water Agency URA	Elicitation of local expert knowledge	*10 January 2011*
Interview of José Ignacio Arrieta Pérez Diputación Foral de Álava	Elicitation of local expert knowledge	*15 March2011*
Interview of Daniel Fernandez, water utility of Bilbao CABB	Elicitation of local expert knowledge	*30 March 2011*
Interview of Clemente Prieto, Energy company Iberdrola	Elicitation of local expert knowledge	*6 April 2011*
Interview of Jesús Gonzalez Piedra , Cantabric river basin agency	Elicitation of local expert knowledge	*1 April 2011*
Interview of Cesar Ferrer, and Rogelio Galvan, Ebro river basin agency	Elicitation of local expert knowledge	*5 April 2011*
Interview of Jose antonio Aranda Euskalmet and Pedro Anitua Aldekoa from Basqeu civil protection	Elicitation of local expert knowledge	*5 May 2011*
Meeting with the Basque Water agency	Discussion about preliminary results with the Basque Water agency (Gonzalo Cabo))	*3 October 2011*
W2A Bilbao Meeting	Organisation of the annual workshop of W2A. Project partners and advisory board	*3-4 October 2011*
Meeting with Irstea (Montpellier, France)	Networking and discussion about methods for droughts risk assessment	*12 February 2012*
Participation in "the 3 days of Water"	International Workshop on water resource management, Venice (Itraly)	*26-28 September 2012*

Po River Basin Activities

Activity	Purpose	*Date*
Organisation of the International Workshop on "Resilience - Harnessing Science for Better Disaster Management", Venice	Knowledge transfer among projects Networking / development of networks	*6-7 October, 2010*
Participation to the International Conference of the Alpine Convention "Water in the Alps", Venice	Knowledge transfer among projects Networking / development of networks	*25-26 November, 2010*
Final IWRM-net conference, Brussels	Knowledge transfer among projects Networking / development of networks	*1-3* December, 2010
Stakeholder meeting with Francesco Puma, Po river basin authority	Elicitation of local expert knowledge	*29 September 2010* *20 December 2010*
Stakeholder meeting with Cristina Sassi, Parma Municipality	Elicitation of local expert knowledge	*11 October 2010*
Stakeholder meeting with Paola Manfrini, IREN water utility	Elicitation of local expert knowledge	*29 September 2010*
Stakeholder meeting with Rossana Bissoli, Region Emilia Romagna	Elicitation of local expert knowledge	*14 October 2010*
Field visit and interviews: Parma, Ferrara and Trebbia river basin	Elicitation of local expert knowledge	*January to July 2011*
Participation to the pricing water – towards an effective, efficient and socially fair pricing schemes and financing arrangements	Elicitation of local expert knowledge Knowledge transfer Networking / development of networks	*8 June 2011*
Focus group meeting on urban vulnerability to drought , Parma	Elicitation of local expert knowledge Knowledge transfer	*11 July 2011*

	Networking / development of networks	
Focus group meeting on urban vulnerability to drought, Ferrara	Elicitation of local expert knowledge Knowledge transfer Networking / development of networks	*21 July 2011*
Participation to the International Research Workshop on Economics of Natural Disasters, Venice	Knowledge transfer Networking / development of networks	*February 10-11, 2011*
Participation to the Joint Workshop on Surface and Ground Water Management in Italy and the Netherlands, Venice	Knowledge transfer Networking / development of networks	*October 5, 2011*
Participation to the Meeting of the European Expert Network on Water Scarcity and Drought, Venice	Knowledge transfer Networking / development of networks	*October 13-14, 2011*
Participation to "Giornata mondiale dell'acqua", Bologna	Knowledge transfer Networking / development of networks	*March 22, 2011;*
Participation to "Miglioramento dell'uso idrico nella filiera agroalimentare", Bologna	Knowledge transfer Networking / development of networks	*June 22, 2011;*
Participation to "Mitigazione del rischio di siccità e cambiamenti climatici: quali priorità?", Catania	Knowledge transfer Networking / development of networks	*October 10, 2011.*
Participation to "Le magre del Po. Conoscerle per prevederle, cooperare per prevenirle", Parma	Knowledge transfer Networking / development of networks	*October 27, 2011.*
Partecipation to "Strumenti economici per una gestione sostenibile delle risorse idriche urbane", Bologna	Knowledge transfer Networking / development of networks	*November 11, 2011.*
Participation to the IWRM Net SCP Mid-term event, Lyon, France.	Knowledge transfer among projects Networking / development of networks	June 25th, 2012
Organization of "The 3 days of Water" event	International Workshop on water resource management, Venice (Italy) and Italian workshop with main stakeholder	*26-28 September 2012*

Weser river basin Activities

Activity	Purpose	Dates
Final *IWRM*-net conference, *Brussels*	Knowledge transfer among projects Networking / development of networks	*December 1-3, 2010*
Interview Harald Windeler, region of Hanover, environment department	Knowledge transfer among projects	*January 19th, 2011*
Participation on meeting of project "KlimaFolgenManagement" in Uetze, Lower Saxony: Influence of climate change on regional water balance	Knowledge transfer among projects	*April 14th , 2011*
Interview Dr. Ute Simon, project coordinatior of project "KlimaFolgenManagement"	Elicitation of local expert knowledge	*May 9th, 2011*
Interview Ekkehard Fricke, irrigation association	Elicitation of local expert knowledge	*May 17th, 2011*
Interview Dirk Schmidt, city of Hanover, environment department	Elicitation of local expert knowledge	*May 17th, 2011*
Interview enercity (Katja Fürstenberg, Andreas Rausch)	Elicitation of local expert knowledge	*May 30th, 2011*
Interview Heinz Pyka, fishing association Hannover	Elicitation of local expert knowledge	*September, 1st 2011*

Interview Dr. Reinhard Martinsen, regional allotment garden association of Hannover	Elicitation of local expert knowledge	*September 16th, 2011*
Interview Schulze, Federal Waterways and Shipping Authority	Elicitation of local expert knowledge	*September 2011*
Weser workshop "Resilience to climate change in the region of Hanover and the Weser River Basin"	Elicitation of local expert knowledge Knowledge transfer Networking / development of networks	*May 14th, 2012*
IWRM Net SCP Mid term event, *Lyon*, France.	Knowledge transfer among projects Networking / development of networks	*June 25th, 2012*
Capacity Development Workshop	Developing capacity in community resilience (mitigation and adaptation)	*Planned Dec 2012*

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