BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES TOWARDS A SUSTAINABLE EUROPE

Subgroup: Agriculture

Case-study: Adaptation of water for rice in a coastal wetland, Doñana, Spain

(UPM, Spain)

Date: February 2015

1-0

Case study developed by:

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Project:

FP7/ Project BASE [2012-2016]

Date of release:

12/06/2015

Purpose of this document:

"The Case Studies Living Document (CSLD) will be the document that each case study leader will use to share the information that (i) characterize and give context to its case study, (ii) the goals within BASE, (iii) the methods used and mainly (iv) a synthesis of the results that that case study is providing to BASE project. This will allow the CS leader to understand how its own case is going (having a good overview), but also (v) will allow the sub-group to which the case study belong to know what is happening and what can be done (mainly on synergies and so on) as well as to (vi) WP4 & 5 coordinators to use that information to report (including each WP task leaders). These living documents will also (vii) allow WP6 & 7 partner to know the information."

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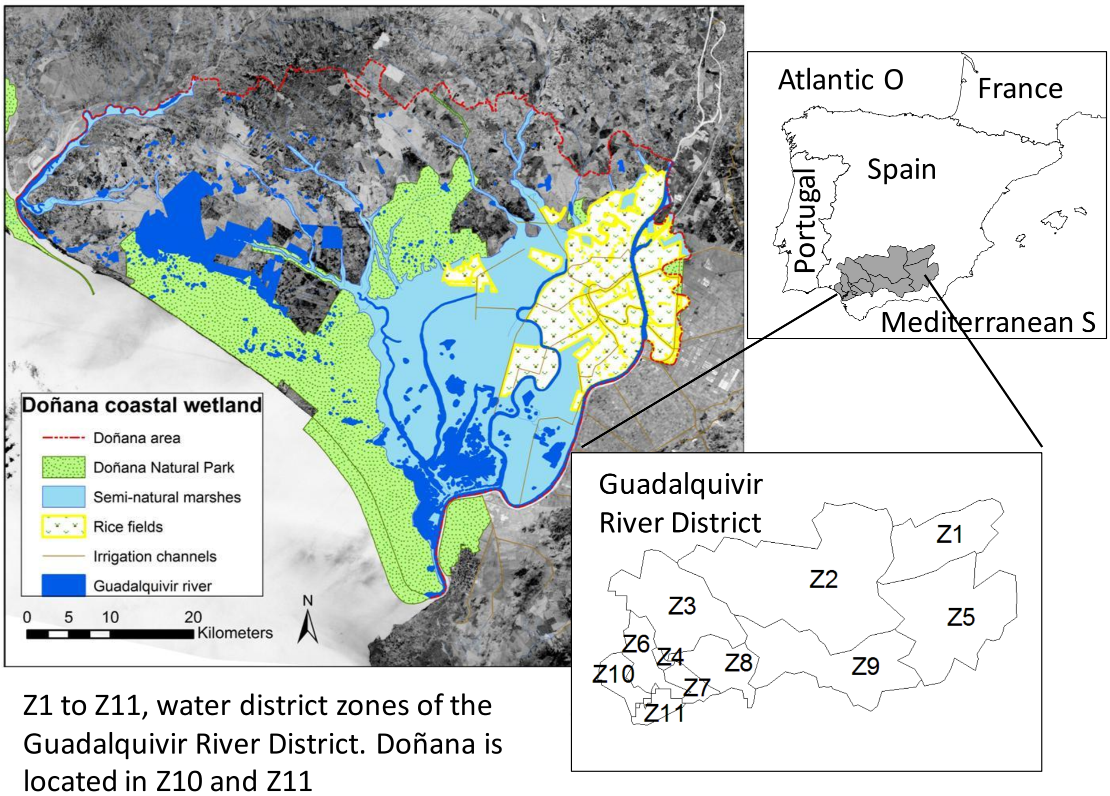
1. General Case Study Description Location

(Please insert the coordinates of the geographical centre of your case study and additionally the area of the entire are under investigation. For a city, for example, use the city centre and the area of the municipality. Illustrate in the map the area in study)

The Doñana coastal wetland is a complex socio-ecological system where the rice production and the wetland ecosystem show a great dependence on water and climate and any change of these factors may alter the state of the environment and local livelihood security.

A. Location

GPS: N 37°00'00"N / W 6°30'00"
Area: 1,776 km^2



Z1 to Z11, water district zones of the Guadalquivir River District. Doñana is located in Z10 and Z11

Figure 1. Geographical location of the Doñana coastal wetland and the Guadalquivir River Basin District

B. Case Study Summary

(Máx500 words)

Rice production in coastal wetlands provides critical ecosystem services that range from flood control to wildlife habitat. In the Iberian Peninsula rice was introduced in the 10th Century. Today Iberian rice accounts for about one quarter of the total rice production of the European Union, almost exclusively cultivated in the coastal wetlands of Spain, with permanent flooding. The intensive water management required to produce rice stands at a crucial point since freshwater supply is deteriorating at an unprecedented rate. Here we explore flexible adaptation options to climate change in the Doñana wetlands—a world heritage and biodiversity site— from two points of view: What are the policy options for agricultural water management in view of climate change? How can informed stakeholders contribute to better adaptation? The first question is addressed by simulating water availability to farmers with the WAAPA model (Garrote et al., 2014) under a range of adaptation policy options derived from the view of the local communities. The second question was addressed by means of participatory research. Adaptation options are framed according to the local environmental, social and policy context. Results suggest that perception on the potential role of new water infrastructure and farming subsidies dominates the view of local communities. The choices of the stakeholders that could be simulated with the hydrological model were quantified in terms of additional water availability for the rice farming, therefore providing a quantitative measure to the qualitative solutions. Information provided during the study shaped the final adaptation options developed. Our research contributes to the definition of sustainable rice production in Europe.

C. Context

(Máx500 words) *If relevant to the understanding of the Case Study , please provide any contextual information of the region, history, etc of the case study*

The Doñana coastal wetland is recognised of international importance and declared as a Ramsar Wetland, UNESCO World Heritage Site and Biosphere Reserve for being one of the richest natural ecosystems in Europe (García Novo and Marín Cabrera, 2006). The coastal wetland of Doñana is located in the lower part of the Guadalquivir River District (Southern Spain) on the Atlantic coast of Andalusia, the protected area cover an area of over 121,600 hectares under the protection status of Doñana Natural Park and in the eastern side is also located the largest rice (*Oryza sativa L.*) farming area of the country (ca. 36,000 hectares) (Figure 1). There are a population of nearly 213,839 inhabitants in the Doñana area, whose activities are mainly addressed to agriculture and tourism and in turn the wetland provides key ecological services such as a stepping-stone in the migration route for birds and waterfowl, a home to many endemic and threatened species, regulation of the local hydrologic cycle and provision of landscape services (Martín-López et al, 2011).

The Guadalquivir River District with around 650 km of length and 57.527 km² of area, amounts 7.022 hm^3/year in average of renewable water resources from which 4,007.73 hm^3/year are used mainly for agriculture (87%),

domestic use (11%), industrial use (1%) and energy (1%) (CHG 2013). Rice farming is the main source of income for the local population but as well is one of the most water intensive crops of the river basin (De Stefano et al. 2014). Rice farming occupies the 4.2% of the irrigated area and requires over 10,400 m^3/ha/year of water to achieve yields between 9 to 10 t/ha, it accounts a total of 366 hm^3/year, the 14.3% of the annual regulated water resources of the river basin (CHG 2013). The irrigation system for the rice cultivation consist in taking water directly from the Guadalquivir River and flooding the fields until 20 cm of water, depending on the crop needs for each development stage, throughout channels. The semiarid conditions and the salinity of soils make difficult the cultivation of many other crops in the rice area. The flooding irrigation system allows tolerable levels of oxygen, temperature and salinity for growing the rice (maximum concentration of 2g/l of salt in the water) whilst avoids the emergence of a saline crust in the top soil (Aguilar 2010). Further, the sea intrusion increases largely the salinity of the water in the estuary and the Guadalquivir Basin Authority has to provide for dam releases upstream from the rice area to improve the quality of irrigation water.

So far, rice farmers in Doñana received approximately 1,670 €/ha as public subsidies (within the framework of the CAP, Regulation EC/1782/2003) and if they met the integrated production commitment that includes a group of best management practices, they also received 398 €/ha (Regulation EC/1257/1999). Currently, rice farmers will have to meet the measures included into the CAP greening to perceive the equal subsidies. Thus rice production can be considered profitable for farmers since the average cost of producing rice in Doñana is over 1,496 €/ha (reduced due to a highly mechanized agricultural system and higher education training of farm managers that implement precision agricultural methods) and rice price usually ranges between 2,000-2,200 €/ha on average (Aguilar, 2010).

The Doñana coastal wetland is a complex socio-ecological system where the rice production and the wetland ecosystem show a great dependence on water and climate and any change of these factors may alter the state of the environment and local livelihood security.

D. Brief General Information on Climate Change and related issues

(Máx 2000 words) *Please state which is the European climate zone of the case study and insert any information regarding the current available information regarding the case-study, namely expected impacts, scenarios.*

Recent history has shown the failure of the socio-economic and agricultural system in Spain to adapt to current developmental needs and environmental requirements (Iglesias et al, 2012a). For instance, water management institutions and available water reserves were not able to cope with sustained droughts in themid-1990s. Furthermore, over-allocation of existing water resources in several river basins is stressing many irrigation-dependent agricultural systems and causing others to cease production. Existing institutions and the traditional water policy community have not been able to reconcile the interests of the agricultural, hydroelectric and urban sectors with increasing social demands for ecosystem maintenance. There remains a pervading social perception in Spain that droughts are unavoidable catastrophic events (Iglesias et al, 2011; Iglesias et al, 2012a), instead of a risk to be managed. In addition, the weak cooperation among different institutions, and the fragmented roles of the State, the regions, and the river basin authorities, often result in conflicts and impediments for implementation of existing legislation and management actions, and limit the adaptive capacity of the Spanish irrigation sector to the risks inherent to climate change processes (Iglesias et al, 2012b).

The Europe 2020 strategy promotes the development of a greener, more environmentally friendly economy for the European Union countries. The European Environment Agency (EEA, 2012) supports the idea that healthy and resilient coastal ecosystems may provide services needed for this green economy whilst maintaining human wellbeing. However, the challenge remains in defining how to move towards sustainability in practical terms. Coastal wetlands provide a challenging example that combines the economic interests of rice producers, the policy interests of rural development policies, and the environmental interests of water conservation policies.

The Doñana region is a coastal wetland in the Guadalquivir River Basin District of Southern Spain, where water is shared among the natural and the artificial wetland. The recent high temperature and drought episodes are influencing the view of local communities about the need for adaptation in the Doñana natural ecosystems and agricultural systems (De Stephano et al. 2014). The water district is already under environmental pressure (Willaarts et al 2014; EEA 2012), the coastal vulnerability to sea level rise is high (Ramieri et al. 2011; Ojeda et al. 2009), and the potential increase of irrigation demand is very high (Iglesias et al., 2012).

Drought episodes of the past fifty years in the Sothern Europe aggravate the structural water deficit in the Doñana coastal wetland and the policy strategies undertaken have been capable to deal with extreme situations, but ineffective to solve the conflict among users, especially with the environment (Iglesias et al. 2008a; Iglesias et al., 2008b). Further, the water competition and conflicts will be increased due to a major pressure on freshwater resources as a result of climate change impacts, increased population, pollution problems from agriculture intensification and fragmented and uncoordinated adaptation policy strategies (Iglesias 2009). There is a need of reaching a balance among equity, economic security and the environment by flexible adaptation options that may deal with the increasing pressure on freshwater resources and in turn reduce the conflict among users in the case study region.

The local actors' views need to be considered for designing environmental policies since they may reveal a great deal of helpful information to approach possible adaptation pathways closer to the reality (Picketts et al., 2013). For instance, Sánchez et al. (2014a) found by public consultation that the main drivers to encourage the adoption of new mitigation and adaptation measures by Spanish farmers were pro-environmental concerns, financial incentives and access to technical advice. Furthermore, García-Llorente et al. (2011) found by public consultation in Doñana that the environmental policy strategies should be aimed to increase education programs regarding conservation policies specially addressed to male ageing population with lower education levels.

Several hundred studies have made significant efforts to find climate change adaptation measures (IPCC, 2014) and many in Doñana are contributing to the definition of strategies that can be agreed among the local actors (De Stefano et al. 2014), among the environmental policy design (Martin-Lopez et al., 2011) and among the economic choices (Berbel et al., 2011). The case study aims to address the social and environmental challenges for adaptation of the Doñana coastal wetland. We combine two sources of information to explore flexible adaptation options for the rice farming and the natural ecosystem. First, we define the magnitude of the impacts and the effects of policy by modelling the river basin system. Second, we conduct a participatory data collection process to inform on the social challenge.

Understanding how forces outside agriculture influence both water for the environment and agriculture is not easy. However, in our study area, there are a number of factors that are clearly recognized:

**The climate is changing, increasing temperatures and decreasing precipitation in the area, making Doñana a hotspot in the debates over climate change adaptation in Europe.

**Increasing water withdrawals and water depletion for irrigation may be good for the economic growth of a limited number of rice producers, but clearly bad for the environment.

**Agricultural subsidies have supported the income of rice producers, but have failed to generate viable rural development alternatives and distort the water needs of agricultural practices.

**Globalization presents a challenge for locally produced rice without the CAP's price support systems, as CAP subsidies compensate for the low prices that Spanish producers have to maintain to be competitive with imported rice.

**Higher energy prices increase the costs of pumping water, applying fertilizers, and transporting products. Greater economic burden is expected for rice producers. The increasing price of energy also affects the economic viability of more water efficient but energy intensive rice irrigation practices.

E. Existing information on the Case Study's adaptation history

(Máx 2000 words)*Please insert a short resume of the Case study existing information related to Climate Change Adaptation (major goals, plans, measures and timelines already defined or implemented),important Milestones in its "Adaptation Journey" as well as relevant state-of the art regarding the implementation of Adaptation Strategies and Specific Measure*

F. Connection with other research projects:

(Please list and shortly describe previous or ongoing research projects directly related with the Case Study) Please write the name and summary of the project, relevant partner institutions, year of beginning and end of project)

WWF Adaptation

Animal Change, FP7

WasserMed, FP6

This research was supported by the Spanish Biodiversity Foundation project of Adaptation in Doñana, implemented and coordinated by WWF-Spain

G. Case ID, Typologies and Dimensions

Having in mind the following BASE Objectives; Categories of Case Studies, please fill in the following table.

BASE OBJECTIVES
1.Compile and analyse data and information on adaptation measures, their effectiveness. (…)
2.Improve current, develop new and integrate methods and tools to assess climate impacts, vulnerability, risks and adaptation policies (…).
3.Identify conflicts and synergies of adaptation policies at different levels of policy making with other policies (including climate mitigation) within and between sectors. (…)
4.Assess the effectiveness and the costs and benefits of adaptation strategies to be undertaken at local, regional, and national scales using innovative approaches (mainly by integrating bottom-up knowledge/assessment and top-down dynamics/processes) with particular attention on sectors of high social and economic importance.
5.Bridge the gap between specific assessments of adaptation measures and top-down implementation of comprehensive and integrated strategies.
6.Use and develop novel participatory and deliberative tools to enhance the effective use of local contextualized knowledge in adaptation strategies to assess perceptions of adaptation pathways and their co-design by citizens and stakeholders.
7. Disseminate findings by sharing the results of the project with policy-makers, practitioners and other stakeholders. (…)

CASE STUDIES CATEGORIES
Public administration (municipality, regional, national, European)
Research and education Centres (universities, research centres, projects and groups, schools)
Public companies
Companies (farms, SMEs, big businesses)
Social enterprises (cooperatives, non profit companies, woofing farms, etc)
Consortiums (partnerships, campaigns),

NGOs (environmental NGO, local development NGO, charities, etc)
Transition Initiative
Ecovillage
Informal groups, Movements

Case ID			Typologies and characterization				
Country & Name of CS	BASE Objectives to be answered by the CS	Category of case study	Territorial zones	Scale	Process Direction	Temporal Definition	Timescale[1]
Adaptation of water for rice in a coastal wetland, Doñana, Spain	☑ Objective 1 ☐ Objective 2 ☑ Objective 3 ☑ Objective 4 ☑ Objective 5 ☑ Objective 6 ☑ Objective 7	A, B, C, D	☑ Rural ☐ Urban ☐ Coastal ☑ River Basin	☑ Local ☐ Regional ☐ National ☐ Transnational ☐ European /Global	☑ Bottom-Up ☐ Top-Down	☐ Retrospective ☑ Prospective	2012–2015

H. Impacts, Sectors and Implementation

Please tick the relevant boxes for impacts and implementation and insert the number 1 for primary sector and the number 2 for secondary sector.

[1]Please insert year of start and year of end of case study.

Impacts		Sectors		Implementation	
Primary CC Impacts (Climate-Adapt)	Primary CC Impacts (BASE)	Primary and Secondary Sector (Climate Adapt)	Primary and secondary Sector (BASE)	Implemented[2]	Phase of Implementation[2]
☑ Extreme Temperatures ☑ Water Scarcity ☑ Flooding ☐ Sea level Rise ☑ Droughts ☑ Storms ☐ Ice and Snow	☑ Extreme temperatures ☑ Water scarcity ☑ Flooding ☐ Coastal Erosion ☑ Droughts ☑ Soil Erosion ☑ Vector Borne Diseases ☑ Damages from extreme weather related events (storms, ice and snow)	☑ Agriculture and forest ☑ Biodiversity ☐ Coastal Areas ☑ Disaster risk reduction ☑ Financial ☐ Health ☐ Infrastructure ☐ Marine and Fisheries ☑ Water Management ☐ Urban	☑ Agriculture ☑ Biodiversity & Ecosystems ☐ Coastal and Marine systems ☐ Energy ☐ Health and Social Policies ☐ Transport ☐ Production Systems and Physical Infrastructures ☑ Water resources ☐ Tourism	☐ Yes ☑ Ongoing ☐ No	☑ Assessment ☑ Planning ☐ Implementation ☐ Monitoring ☐ Evaluation

I. Importance and Relevance of Adaptation

Please tick the relevant box for the case study.

☑ Case developed and implemented as a climate change adaptation measure

[2] When the case study consists of a public administration with a top down approach, implementation can be an approved legislation or regulation. When the case study is about practical adaptation measures like a sand dune, for example, implementation should be considered finished when the dune is built in situ.

☐ Case developed and implemented and partially funded as a climate change adaptation measure

☐ Case mainly developed and implemented because of other policy objectives, but with significant consideration on climate change adaptation aspects

2. Case study research Methodology

a) Research Goals

(Máx 500 words) *Please insert which are the General Goals for the case study as well as how will the case study contribute for BASE projects and BASE key research questions.*

The research goal is to explore flexible adaptation options to climate change in the Doñana wetlands from two points of view: What are the policy options for agricultural water management in view of climate change? How can informed stakeholders contribute to better adaptation? The first question is addressed by simulating water availability to farmers with the WAAPA model (Garrote et al., 2014) under a range of adaptation policy options derived from the view of the local communities. The second question was addressed by means of participatory research. Adaptation options are framed according to the local environmental, social and policy context.

b) Stakeholders involved

(Máx 2000 words) *Please insert any information about the stakeholders involved in the adaptation process with which you will relate to, namely their nature, involvement in the process, etc. If possible highlight the decision-making process as well as the leadership process for Climate Adaptation Strategies. Do Mention if there exists any kind of public engagement and participation within the Adaptation process.*

Criteria for selecting stakeholders and sample size

Since the mid 1980s there is a growing awareness that the stakeholder may be crucial for effective change and adoption of innovation (Freeman 1984; Eden and Ackermann 1988; Bryson 2004). The fundamental principle is that there are a number of people, organisations and groups, who are critical to the adaptation viability and success. There has been a great deal written in the stakeholder literature on the definition of who or what is a stakeholder. There are numerous definitions of stakeholders; here we consider that stakeholders are groups of individuals with power to directly affect the adaptation future either by supporting or constraining actions (adapting the business definition of Eden and Ackermann (1998) to the adaptation objectives) and recognise that the stakeholders' views will change depending on the specific issue that is being addressed (see Cummings and Doh 2000; Glicken 2000). Following these concepts, we selected stakeholders in two steps: (1) Identification of the groups who have the

potential to affect or may be affected by adaptation policies; and (2) Analysis of their power or influence in the adaptation decision in an influence vs interest map (Eden and Ackerman 1998).

Power versus interest grids typically help determine which players' interests and power bases must be taken into account in order to address the problem or issue at hand. As result we grouped the stakeholders in a matrix with four categories (Figure 3). First, the critical players are the farmers, since they have high influence and high interest. Second, the context setters are the policy makers, which have high power but lower interest. Third, the significant players are the environmental groups, which have high interest and lower power. Finally, the citizens' group includes the less significant players, with lower interest and lower power. Recognising the importance citizens' opinion for setting values in adaptation, we assumed that the expert scientist group could represent an aggregated view of the population (see below). This assumption is clearly flawed, but may be valid in the absence of data derived from a large survey, that is completely out of the scope of this study. Therefore the views of the expert panel are not formally considered in the study; the reason to include this group in the description is to communicate the research process.

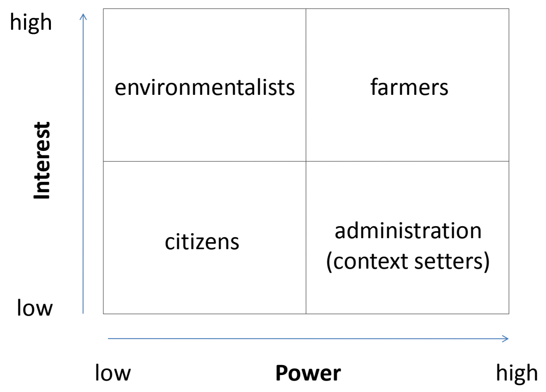


Figure 3 Criteria for selecting stakeholder groups, adapted from the theoretical power versus interest grid of Eden and Ackermann (1998).

Once the groups were defined, deciding who should be involved is a key strategic choice. In general, people should be involved if they have information that cannot be gained otherwise, or if their participation is necessary to assure successful implementation of adaptation strategies. These two aspects, together the available volunteer participants, guided the selection of stakeholders for the one-to-one long interviews (see Annex 1).

In all groups, the number of available volunteer participants was very low, limiting the potential sample size. This raises the question of the representation of the sample. In relation to the representation, it is recognised good results can be achieved with just a few interviews, as data become saturated, and data analysis indicates that all themes can reach saturation, meaning additional participants would likely not have added to the depth or breadth of parent responses (Sandelowski 1995; Carlsen and Glenton 2011).

In this study area, the position of the farmers is extremely well defined, since all want to maintain or increase the water supply for rice cultivation. Over 90% of rice farmers in Doñana belong to farmer associations (i.e., Farmer Association body, such as Farmers Advisory Services, Irrigation Communities, Cooperatives or Rice Farming Federations and Unions; see Aguilar 2010). These services include only private members with a technical profile or experienced farmers, and do not include representatives of the local or regional administration. The rice farmer associations provide services to manage irrigation, to the processing of rice after harvest and to facilitate the marketing to the farmers. They also offer technical advice and legislative information, including regular supervision and follow-up of the rice fields and production. The high level of association between rice farmers makes them a strong lobby with very uniform interests. For the interviews we selected members from the five organisations that represent 90% of the farmers, with the aim of providing the representation of the rice farmers in the area as accurate as possible. The Administration body refers to the public service organization which has control on water resources policy, water management and irrigation planning in the Guadalquivir River Basin District. It includes the River Basin Authorities and public officials, with almost absolutely uniform view on the possible solutions facing climate change. The environmentalist body is a lobby group representing the environmental rights and the nature welfare of the Doñana coastal wetland by strategic actions in water management and new regulations; this group has a uniform voice since the 1960s claiming more water for the natural wetland.

Primary data collection

Primary data on observed impacts in the coastal wetland and possible adjustments in view of climate change was collected by means of two qualitative social research methods used in sequence: semi-structured interviews and an expert panel. These are sampling techniques commonly used in policy research (Martín-López et al, 2011; Harrell and Bradley 2009; Ingram and Morris 2007).

Semi-structured interviews were conducted with a standardized guideline to ensure that the researcher covers the material and with an open framework with some discretion about the order in which questions were asked. This sampling method is adequate when the objective is to look deeply into a topic and to understand thoroughly the answers provided (Harrell and Bradley 2009). The interviewer provided information about climate change impacts on water resources in the Guadalquivir River Basin District (included in the Results section) and received information about the observed changes in the coastal wetland and potential adjustments of current water management that affects rice production and the natural ecosystem. In particular, the interview aimed to identify the flexible adaptation measures that could be effective from the social and environmental points of view. A guideline to the interviews was prepared in advance, however the interviews resulted in additional discussion topics that contribute to understand the barriers to implement the potential technical measures.

The semi-structured interviews aim to obtain specific qualitative information about observed climate impacts and possible adjustments from a sample of the population. The main advantage of the method is that it encourages two-way communication, those being interviewed can ask questions to the interviewer, provides arguments for answers, and encourages discussion on sensitive issues. The main limitations are derived from the small sample size and the lack of trust that the interviewed may have about the confidentiality of the responses.

The expert panel assisted in the formalisation of the research questions derived from the semi-structured interviews. The interview survey was conducted during 31 January, 1 and 2 February 2012. To supply a broad outline on observed climate impacts and possible adjustments, eleven key participants from relevant sectors of the coastal wetland were encouraged to give their input (Table 2). The requirements for the participants' selection were: i) to be working on activities related to the rice production and the natural ecosystem during the last decade; ii) to have an extensive knowledge about the rice productive sector and to have regular contact with the rice farmers; ii) to have an extensive knowledge about the welfare of the wetland and the natural ecosystem functioning; and iii) to be informed on the water management requirements to cope successfully with the rice production and the natural ecosystem.

Table 2. Description of the public consulting conducted in terms of type of consultancy, number of participants and structure of the sample

Type of consultancy	Date and venue	Number of participants	Type of participants
Semi structured individual interviews to local actors	31 January to 2 February, 2012 in Doñana area	11	Farmer Association (5), Administration (3), Environmentalists (3)
Expert panel to experts / scientists	20 April of 2012 in Madrid	3	Research scientists in Hydrology (1), Agriculture (1) and Economics (1)

The resulting information of the consulting process was also used to inform local stakeholders of the rice farming area by organizing two workshops about the local climate change risk and adaptation with a total of fifty-one participants (De Stefano et al. 2014).

c) Methodology

(Máx 2000 words) *Please insert what will be your research approach regarding this case study, how did you define it (did it include participatory sessions or not) and how you will implement it during the BASE Project period.*

Our methodological framework combined two information sources to explore flexible adaptation options for the rice farming and the natural ecosystem in the coastal wetlands of Doñana (Figure 2): First, the WAAPA model is used to estimate the effect of exposure to climate change and of different adaptation policy options in water availability, providing information on the environmental challenge. Second, semi-structured interviews and an expert panel, inform on the view of local communities on climate change risk and adaptation measures to rice production and the wetland, providing information on the social challenge.

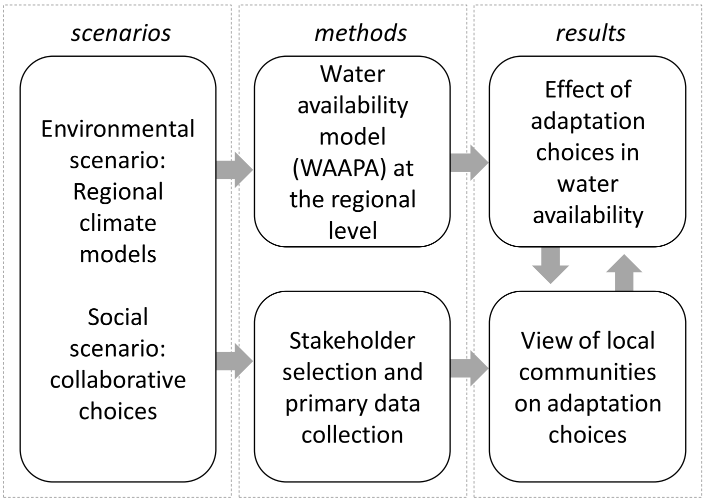


Figure 2. Methodological framework

Climate change is clearly defined in the WAAPA model, since it is an input for the simulations. The climate change scenarios for 2071-2010 are explained below. Although these climate scenarios are also presented to the stakeholders, it is inevitable that these scenarios are compared to the perceived current and past water scarcity and climate variability. It is important to notice that water scarcity is a permanent fact in the area and climate scenarios intensify the scarcity level.

Modelling water availability and policy scenarios

The effect of climate change and policy on water availability for irrigation and for the natural ecosystem was estimated with the WAAPA model (Garrote et al., 2011; Garrote et al., 2014). The quantitative analysis provided support for the selection of adaptation policy options that inform local stakeholders.

The WAAPA model (Water Availability and Adaptation Policy Analysis) calculates Maximum Potential Water Withdrawal (MPWW), defined as the maximum water demand that could be provided at a given point in the river network with the available water infrastructure (i.e., reservoirs, dams and water transfers), satisfying management and environmental constraints. MPWW is associated to a given demand type, which implies a minimum required reliability and certain seasonal variation. In all cases urban supply is associated to population and has higher priority than irrigation. Water for ecosystems has also a higher priority than irrigation: The amount of water allocated for ecological flows is defined in each sub-district following the specification of the national regulation on hydrological planning

Model architecture is summarized as follows: (a) Satisfaction of the environmental flow requirement in every reservoir with the available inflow. Environmental flows are passed to downstream reservoirs and added to their inflows. (b) Computation of evaporation in every reservoir and reduction of available storage accordingly. (c) Increment of storage with the remaining inflow, if any. Computation of excess storage (storage above maximum capacity) in every reservoir. (d) Satisfaction of demands ordered by priority, if possible. Use of excess storage first,

then available storage starting from higher priority reservoirs. (e) If excess storage remains in any reservoir, computation of uncontrolled spills.

The MPWW analysis was applied to estimate the exposure of the Guadalquivir sub-districts to climate change. The comparison between the MPWW for irrigation in the control and in the climate change scenario provides a proxy variable to estimate exposure to climate change. In this study we consider that urban demand is fixed, because it is linked to population, which in the region under analysis is not expected to change significantly in the next 50 years (OECD, 2012). Water for ecosystems is estimated following the environmental flow requirements specified in the national regulation, which establishes a range between the 5% and 15% quantiles of the marginal distribution of monthly flows in current natural conditions. The central value, 10%, was adopted and it was considered constant. According to climate change projections, this assumption may be perceived as conservative, since streamflow is expected to decrease sharply in the region, but it may underestimate or overestimate future ecosystem water demand depending on future land use and environmental regulations.

Water policy scenarios are constructed aiming to maintain adequate reliability for urban, ecosystem and irrigation demands. The effect of the adaptation effort is estimated from the difference between water availability for irrigation in the control and in the climate change scenario. This is based on the assumption that in the control period irrigation demand is similar to MPWW for irrigation. The assumption is well grounded for the study region, a water scarcity Mediterranean region, where water resources are developed (i.e., infrastructure and management) to satisfy existing demands. The larger the difference between current and future water availabilities for irrigation, the greater the adaptation policy effort required to compensate for climate change though adaptation.

The effect of policy scenarios here is calculated as the increase in future water availability resulting from the implementation of each policy. This study considers four adaptation policy scenarios aiming to reduce the irrigation demand that would be required in the climate change scenario in order to restore the same level of performance that is observed in the control scenario. Demand reduction is not the only policy alternative to reach the objective of adequately supplying the multiple demands of water in the area. In addition to demand reduction, this study considers four adaptation policy measures. Policy option 1 (urban policy) implies to improve urban water use efficiency and reach the target of 175 l/person/day supplied in urban areas. Currently this amount is 300 l/person/day, a value that is considered too high. Concrete examples for implementing this policy could be re-use of urban water or improvement of water technical efficiency within cities (supply management policy), imposed reduction of water per capita use (demand management policy), or water rights exchange programs (supply management policy). The data on urban water use of 300 l/pd is the reference value adopted in the Hydrological Plan of the Guadalquivir River Basin District in time horizon 2015 (taken as “current” scenario) (CHG 2013). The value of 175 l/pd is taken as a target value estimated from the water supply systems in Spain that currently show the smallest per-capita consumption reported (value 195 l/p.d in the Consorcio de Aguas de Tarragona, plus a further 10% increase in efficiency) (CHE 2014).

Adaptation Policy 2 implies a reduction of the environmental flow requirements (from the 10% to 5% quantile of the marginal monthly distribution of runoff). This assumption is clearly challenged within the current strategy for water management, but it is included here to illustrate the trade-off between water for the artificial wetland and for the natural wetland for the discussion among local actors. Adaptation Policy 3 implies to use the storage available in hydro-power dams for regulating water for irrigation. Finally, Adaptation Policy 4 is reached by improving the overall

water management of the system by expanding the network of water interconnections and applying water resources systems optimization models.

In this study, climate change scenarios are derived from Regional Climate Models (RCM) driven by two greenhouse gas emission scenarios. The use of RCMs is an important tool for evaluating water management under future climate change scenarios (Varis et al. 2004). Nonetheless, it is well known that the output of the RCMs cannot be used directly if there is no procedure that eliminates the existing bias (Sharma et al. 2007). For this reason, in order to analyse the effect of climate change on water availability for irrigation in a regulated system, here we generate climate change projections based on the bias-corrected runoff alternatives (following Gonzalez-Zeas et al., 2014). We use two emission scenarios (A1B and E1, to represent the uncertainty derived from greenhouse emissions policies) and two regional climate models to represent the uncertainty derived from model choice). Climate change input for the WAAPA model was monthly time series of streamflow data obtained from the results of the ENSEMBLES project in two climate scenarios (Table 1). The transient runs (1950-2100) were split in two periods: control climate (1960-1990, Oct 1961 to Sep 1991) and future climate (2070-2100, Oct 2069 to Sep 2099).

Table 1. Climate change scenarios used as input to the WAAPA obtained from the ENSEMBLES project.

Scenario name in this study	Global model	Regional model	Resolution and time frame	ENSEMBLES file	Socio economic assumptions (*)
CRNM A1B	ARPEGE	RM5.1	25x25km, 1950-2100	CNRM-RM5.1_SCN_ARPEGE_MM_25km_1950-2100_mrro.nc	A1B
KNMI A1B	ECHAM5-r3	RACMO2	25x25km, 1950-2100	KNMI-RACMO2_A1B_ECHAM5-r3_MM_25km_mrro.nc	A1B

(*) See Nakiçenoviç et al., 2000

Limitations of the methodology

There are some major limitations of our methodology, derived from the modelling approach and from the consultation process.

The simulation of water availability under climate and policy changes with the WAAPA models have major sources of uncertainty and limitations. The streamflow were derived from the output of regional climate models that include a very crude representation of the hydrological cycle, demands are estimated using globally available data as proxy variables. This is fully explained in Garrote et al. (2015). In addition changes in land use consistent with the climate scenario projections have not been included in the simulations, since the aim was to simulate policy choices for the current wetland system.

A major limitation is derived from the consultation process. Although the three groups of participants selected are reasonably in line with adaptation in the case study, the interview sample is quite small and it is not necessarily representative of all the communities and organizations involved. The study did not address the full range of stakeholders which affect or are affected by climate change adaptation. Here the groups included are likely to have a potential interest and influence in the decision making process of an adaptation strategy, but some actors may be missing due to the limitations in the sample size. A derived shortcoming of the consulting process arises from the current level of conflict between stakeholders having different views on water management. This may have resulted in some degree of mistrust on the confidentiality of their responses. In addition, the consulting process applied in this study only included qualitative information, resulting in difficult comparison among responses and limited in capturing variability among the respondents. The open questions of the semi-structured interviews did not provide enough information for a quantitative analysis. Thus, we identified a portfolio of adaptation options for water resources management rather than seeking consensus on the more cost effective option or priority that could be derived from more quantitative data. Further research is needed in order to incorporate the local knowledge into climate change adaptation local plans and in the wider policy context.

Despite these uncertainties and limitations, the results obtained show a qualitative picture for future water availability in the Guadalquivir basin under a choice of adaptation policy options derived from the consultation. Our findings advance the knowledge of differing climate change strategies at local scale by providing increased comprehension of the stakeholders oppose or support to adaptation options which could be used to incorporate in local adaptation plans.

Summary table

METHODS to be used in Case Studies[3]	YES // NO
Methods for prioritizing adaptation options	
Cost-Benefit Analysis (CBA)	YES
Cost-Effectiveness Analysis (CEA)	NO
Multi-criteria Analysis (MCA)	YES
Analytic Hierarchy Process (AHP)	NO

[3] For descriptions and references of the Methods please refer to Milestone 8. For data requests from specific Work Packages please refer to Deliverable 4.1

Quantification of impacts and relationships between factors affecting adaptation	
Causal Diagrams	NO
Influence Diagrams	NO
Process-based Modelling	NO
Welfare variation analysis under restrictions	NO
Uncertainty and sensitivity analysis	
Probabilistic multi model Ensemble	NO
Monte Carlo simulations (PRIMATE uses this method)	NO
Real option analysis	NO
Climate risk management process	NO
Global sensitivity analysis	NO
Participatory Methods	
Scenario Workshop	NO
Participatory Cost Benefit Analysis (PCBA)	NO
Participatory add-ons to CBA	NO
Participatory add-ons to Multi Criteria Decision Analysis	YES
Participatory add-ons to Adaptation Pathways	NO
Other (add extra lines if necessary):	
Multivariate statistical analysis	x
Qualitative semi-structured interviews	x
Document analysis	x

(Máx 500 words)Please highlight if you have any special need or focus regarding any of these methods and their use on your case study.

d) Case study Timeline

(Please insert and image/graph of the Timeline of your Research Approach, highlighting important milestones and deliverables.)

e) Collaboration with other Partners and Case studies

Collaboration with BASE case studies (see list in EMDESK):

Case: Danish Agriculture; Person: Anders Branth Pedersen and HelleØrsted Nielsen

Collaboration within BASE partners/researchers (EX: for a specific competence):

Name: Gil Penha-Lopes , Maria Coelho, Ines Campos, Filipe Alves , Andre Vizinho ; Partner: FFCUL

Name: Anders Branth Pedersen, Helle Ørsted; Partner: Aarhus

Name: Ad Jeuken, Marjolijn Haasnoot; Partner: Deltares

Name: Anne-Mari Rytkönen; Partner: SYKE

Name: Volker Meyer,; Partner: HELMHOLTZ-ZENTRUM FUER UMWELTFORSCHUNG GMBH – UFZ

f) Research Outputs

(Ongoing work, will be filled in later in the case study development process)

Scientific publications

García de Jalón S, Iglesias A, Cunningham R, Pérez Díaz JI (2014) Building resilience to water scarcity in Southern Spain: A case study of rice farming in Doñana protected wetlands. Regional Environmental Change, 14, 1229-1242

García de Jalón S, Iglesias A, Quiroga S, Bardají I (2013) Exploring public support for climate change adaptation policies in the Mediterranean region: A case study in Southern Spain. Environmental Science and Policy, 29, 1-11.

García de Jalón S, Silvestri S, Iglesias A (2014) Responding to climate change? Behavioural barriers to adopt changes in agricultural communities: an example from Kenya. Regional Environmental Change (accepted)

Garrote L, Iglesias A, Granados A, Mediero L, Martín-Carrasco F (2014) Quantitative assessment of climate change vulnerability of irrigation demands in Mediterranean Europe. Water Resources Management (in press) 10.1007/s11269-014-0736-6

González-Zeas D, Garrote L, Iglesias A, Granados A, Chávez-Jiménez A (2014) Hydrologic determinants of climate change impacts on regulated water resources systems. Water Resources Management (in press)

González-Zeas D, Quiroga S, Iglesias A, Garrote L (2013) Looking beyond the average agricultural impacts in defining adaptation needs in Europe. Regional Environmental Change, 13(1), 1-11

Iglesias A, Garrote L (2014) Adaptation strategies for agricultural water management under climate change in Europe. Agricultural Water Management (in second revision)

Martin-Carrasco F, Garrote L, Iglesias A, Mediero L (2013) Diagnosing Causes of Water Scarcity in Complex Water Resources Systems and Identifying Risk Management Actions Water Resources Management, 27(6) 1693-1705

Plaza-Bonilla D, Arrúe JL, Cantero-Martíne C, Fanlo R, Iglesias A, Álvaro-Fuentes J (2014) Carbon management perspectives in dryland agricultural systems. Carbon Management (in press)

Resco P, Iglesias A, Bardají I, Sotés V (2014) Climate change and wine regions in Spain: risks and opportunities. Submited to Climatic Change.

Iglesias A, Water and people. (2013). In: Navarra A, Tubiana L (Eds) (2013) Regional Assessment of Climate Change in the Mediterranean: Volume 2: Agriculture, Forests and Ecosystems Services and People, Springer, The Netherlands (ISBN10: 9400757719 ISBN13: 9789400757714

Conferences

Title: Building robust strategies for climate proof fresh water supply: Tagus basin: Looking into solutions, dilemmas, responsibilities and cooperation.

Conference: European Climate Change Adaptation Conference. Hamburg.

Month/Year: 03/2013

3. Participation in Climate Change Adaptation

a) Process overview

(Please describe the use of Participatory Methodologies within your case study, namely its integration in the overall Research Methodology explained earlier in the CSLD, the rationale behind it and key expected outcomes – Máx 1000 words)

Objective of the research

Coastal systems in the North-east Atlantic Ocean are expected to experience adverse impacts due to projected sea-level rise and climate change. There is a need to improve the planning by assessment of coastal vulnerability and flexible adaptation from the local scale and engage widely with relevant stakeholders.

The main goal of this research is to assess the climate change risk and what are the potential adaptation options in the Doñana coastal wetlands, a world heritage and biodiversity site with an intensive agricultural activity under scarcity conditions. We aimed to contribute to adaptation plans development in the case study region including the participation of informed stakeholders. The research was completed within the Spanish Biodiversity Foundation project of Adaptation in Doñana, implemented and coordinated by WWF-Spain.

Guidelines for the interviews

Methodology

The interviews aimed to draw a broad outline of the case study's vulnerability based on the expertise and knowledge of local actors and develop a range of flexible adaptation options according to the local environmental, social and policy context.

The interview survey was conducted across different days in February 2012 and eleven key participants from relevant sectors of the coastal wetland were encouraged to give their input. The requirements for the participants' selection were: i) to be working on activities related to the rice production and the natural ecosystem during the last decade; ii) to have an extensive knowledge about the rice productive sector and to have regular contact with the rice farmers; ii) to have an extensive knowledge about the welfare of the wetland and the natural ecosystem functioning; and iii) to be informed on the water management requirements to cope successfully with the rice production and the natural ecosystem.

Interview questions

Type of question	Selected interview question
Introduction	Q1: Name Q2: Background and experience in the region Q3: Employment status
Perception of climate change risks/impacts for the rice farming and the natural ecosystem	Q4: Do you feel that the Doñana socio-environmental system has changed due to climate variability or extreme events (droughts, heat waves, rainfall distributions) over the last 20 years? (E.g. severe droughts of 1979/80, 1991/95 or 2004/05)? Q5: Have you noticed changes in the yields or the growing cycle (shortening/lengthening) of rice crops in the wetland? Q6: Have you noticed changes in the presence or occurrence of pests, weeds and diseases? Q7: Have you noticed changes in the management (e.g. operations, irrigation, use of fertilizers/sprays) of rice crops? Q8: Have you noticed river hydro morphological alterations or changes in the water availability and quality (e.g. salinity of water) in the region? Q9: Have you noticed changes in the distribution of natural vegetation and wildlife? Q10: What factor do you consider as the most harmful for the rice farming and the natural ecosystem in the region?
Perception of flexible adaptation options for the rice farming and the natural ecosystem	Q11: What measures have been implemented to tackle climate variability and climate change? Q12: What strategies have been implemented to ensure water availability? Q13: What importance do you consider that may have strategies to increase water savings? Q14: What adaptation options do you consider the most effective for the rice farming and the natural ecosystem in the region? Q15: What are the main drivers and tools to undertake these adaptation measures and strategies? Q16: What are the main barriers to the implementation of climate change adaptation options in the region?
Other comments	Q17: Are there any other issues that you consider important in relation to the climate change risks and adaptation which have not tried yet in this interview?

Summary of the responses of the interviews

Identification of risks and adaptation options	Farmer association (5)	Administration (3)	Environmentalists (3)
Main risk for the artificial rice wetland	Decreased water availability	Decreased water availability	Decreased water availability
	Increased water salinity	Increased water salinity	Increased water salinity
	Higher temperatures	Higher temperatures	
		Reductions of water stored	
		Heavy rains and higher deposits appearance	
Most effective adaptation, overall	Changes of water management	Water saving	Energy and water savings
	Modernization of irrigation systems	Increased scientific research, field studies and transferring	Increased scientific research, field studies and farmers training
	Water recirculation and reutilization within the paddy	Improved coordination between institutions, aggregated of the information and dissemination	Strategies to conserve biodiversity and ensure the provision of ecosystem services
	New dams construction and other water infrastructures	Improved monitoring and information on water use	Regulations from WFD and the Hydrologic Plan of the Guadalquivir River Basin
		Reduction of the cultivated areas located closer to the sea	Long-term climate change strategies and agreements
		Increased the technical efficiency of the irrigation systems	Increased dissemination, public participation and environmental awareness raising
		Local climate change actions	Organic agriculture
		Dikes construction to contain marine intrusion	
Responsible for implementing adaptation	Administration; rice farming unions and cooperatives	Administration; Rice farming unions and cooperatives; Research groups to facilitate	Administration; Rice farming unions and cooperatives; Research groups to facilitate
Barriers to implement adaptation	The lack of clear actions	Rice farming conservative traditions	Rice farming conservative traditions
	Larger reductions of inputs (water, fertilizers, sprays)	The difficult for generational renewal and change due to aging farmers' population	The difficult for generational renewal and change due to aging farmers' population
	Marine intrusion during drought periods	Farmers' short-term perception of risks and profit-driven principles	Farmers' short-term perception of risks and profit-driven principles
	New CAP environmental requirements	The lack of interest of rice farmers in climate change issues and debates	The lack of interest of rice farmers in climate change issues and debates
	Energy prices	Easy crop management, all the operations are subcontracted	Low labour needs and high water consumption

Identification of risks and adaptation options	Farmer association (5)	Administration (3)	Environmentalists (3)
	Lower yields and quality crops	High subsidies dependence	The lack of environmental awareness
	Irrigation water costs	Clay soils, risks of floods	New CAP environmental requirements
	Extremely competitive and h ighly volatile price sector	The unstable equilibrium of the Doñana system	The lack of accurate irrigation water measures (flow meters)
Risks related to water scarcity	Water availability reductions	Water availability reductions	Water availability reductions
	Turbidity, muddy water	Turbidity, muddy water	Water stored reductions
	Cumulative impacts in the Guadalquivir River Basin affect the rice fields		Cumulative impacts in the Guadalquivir River Basin affect the rice fields
	Erosion problems		
Adaptation to increased water scarcity	Changes of water management	Changes of water management	Changes of water management
	Modernization of irrigation systems	Modernization of irrigation systems	Water saving strategies
	Water recirculation and reutilization within the paddy	Water recirculation and reutilization within the paddy	Water recirculation and reutilization within the paddy
	Laser levelling	Installation of flow meters	Modernization of irrigation systems avoiding new water infrastructures with environmental impact
	New dams construction and other water infrastructures		Efficient solutions for both the rice farming and the natural ecosystem
	Setting of irrigation turns		Long-term agreements on water and climate change management (water markets, water use allocation permits)
	Increased farmers training, technical advice and scientific information		Actions at the basin level leading flexible adaptation strategies to climate change
	New rice varieties adapted to water and heat stress		Regulations from WFD and the Hydrologic Plan of the Guadalquivir River Basin
	Installation of flow meters		
	Reduced energy costs		
Perception of the importance of water saving	High	High	High
Risk related to increased salinity	Increased soil salinity	Increased soil salinity	Increased soil salinity
	Increased salinity in the aquifer	Increased salinity in the aquifer	Increased salinity in the aquifer
			Biodiversity losses
Adaptation to increased salinity	Dam water releases upstream from the rice area	Dam water releases upstream from the rice area	Dam water releases upstream from the rice area

Identification of risks and adaptation options	Farmer association (5)	Administration (3)	Environmentalists (3)
	Flooding irrigation systems to wash soils		Organic production (good farming practices)
	New pipeline to bring in the water directly upstream from the salt water intrusion		
Risk related to increased invasive species, pests and diseases	Ineffectiveness of current plant protection products		Biodiversity losses
Adaptation to increased invasive species, pests and diseases	Integrated production	Integrated production	Integrated production
Risk related to decreased rice productivity and quality	Reduction of the rice cultivated areas	Reduction of the rice cultivated areas	Reduction of the rice cultivated areas
	Lower income		
Adaptation to decreased productivity and quality	Changes of the management (integrated production)	Changes of the management (integrated production)	Changes of the management (integrated production)
	New longer cycle rice varieties (J-sendra de 155 or Puntal 145)	Improved commercialization	New varieties but not including those GMOs
	Modernization and innovative technical measures	Farmers training and environmental awareness raising	Farmers training and environmental awareness raising
			Improved the product processed to be exported (organic products)

The view of local communities: main risks and local adaptation options

Here we present the results of the consulting process (with key local actors and the experts) focusing on a) how the accelerated state of climate change is already affecting the rice production and the natural ecosystem and b) what are the main conflicts and the potential opportunities for societal consensus on local adaptation options.

The results were first generalized into appropriate categories using the topics included in the interview guideline in Annex 1 and expanded in Annex 2. The categorization was conducted by the primary researcher, and then assessed and verified by other researchers and the experts. Table 3 synthesizes the interviews results. The local actors' views fell into the following categories: (1) risks derived from changes in the climate and degree of social concern on them and (2) local adaptation options according to the identified risks. In this second category, we characterise the: current implementation level per adaptation option identified; acceptance (green) or rejection (red) of the local adaptation options by farmers associations; acceptance (green) or rejection (red) of the local adaptation options by environmentalists; and support for (green) or rejection of (red) the local adaptation options from the administration. The white cells make reference to "no opinion" answers.

Table 3. Summary of the view of local actors on climate change risks and adaptation options

Risk derived from changes in the climate / Degree of social concern	Local adaptation option	Current implementation level[(1)]	Acceptability to farmer associations	Acceptability to environmentalists	Support from the administration
	I. Technological measures to face the risk				
Increased water scarcity /High	Water recirculation and reutilization within the paddy rice	M	Green	Green	
	Increase the technical efficiency of the irrigation systems	L	Green	Green	
	Installation of flow meters	L		Green	
	Laser levelling	H	Green	Green	Green
	Additional water infrastructure	n.a.	Green	Red	Red
Increased water salinity /High	Water releases from upstream reservoirs	M	Green	Red	
	New pipeline to bring in the water directly upstream from the salt water intrusion	n.a.	Green	Red	Red
Increased soil salinity /High	Flooding irrigation systems to wash soils	H	Green	Red	
	Organic production (good farming practices)	L	Red	Green	
Increased invasive species and pests /Medium	Integrated production (inputs use efficiency)	H	Green		Green
Decreased rice yield and quality /Low	New longer cycle rice varieties	L	Red	Green	Red
	New rice varieties adapted to water and heat stress	L	Red	Green	Red
	II. Organizational measures to face the risk				
All risks /High	Reduction of the available cultivated surface	L	Red	Green	
	Crop diversification and diversification to others activities (e.g. aquaculture, agro-tourism)	L	Red	Green	Red
	Anticipating local and regional water shortages	L	Green	Green	Red
	Increase monitoring and information on water use and availability at local level	L	Green	Green	
	Setting of irrigation turns	M	Green	Green	
	III. Governance measures to face the risk				
All risks /High	Actions at the basin level leading flexible adaptation strategies to climate change	L	Red	Green	
	Improve transparency and public participation to encourage agro-environmental awareness	L	Red	Green	Green
	Increase scientific research, field studies, dissemination	M	Green	Green	
	Improve coordination between institutions, data sharing	L	Green	Green	Green
	Encourage a long-term perspective in water management	L		Green	Green
	Implement good practices defined in the WFD	M		Green	Green
	Increase in farmers training and technical advice	M	Green	Green	Green
	Supplemental transfer water from the Guadiana new riverbed	n.a.	Green	Red	Red

(1) L: Low implementation level, M: Medium implementation level, H: High implementation level, n.a. not available

The first category describes stakeholders' perception on the risks derived from changes in the climate and the degree of social concern to them. The results of the interviews suggest that that the major risks in the case study area are water scarcity, salinity problems in water and soils, and to a lesser extent increased invasive species and pests and decreased rice yields and quality. Most respondents' perceptions stemmed from the scarcity of water as the main risk to be concerned. A possible reason why water scarcity is perceived to be the most important risk is the fact that it can easily lead to fall of productivity and rice yield reductions and in turn provoke biodiversity losses. The foresee sea level rise projections in the coastal wetland are expected to worsen the water quality in the lower part of the Guadalquivir River Basin, the case study area, due to larger marine intrusion (IPCC 2014; Ramieri et al. 2011; Ojeda et al. 2009). An increased relative water scarcity, together with higher levels of salinity, makes rise conflicts and competition among users over the allocation of water (Rijsberman 2006).

The literature review and the findings of this study suggest that higher temperatures are also expected to change water demands and have direct physical effects on the plant growth and development (IPCC 2013, Hanak and Lund 2012). Pulido-Calvo et al. (2012) found that in dry periods a mean temperature increase of 1°C in low altitude locations of the Guadalquivir River Basin will result in a mean increase of 12% in the irrigation demand on outflows. Rice is particularly sensitive to heat stress and may suffer serious damages during the anthesis to maximum temperatures above 37 °C and especially when it is exposed to water stress during the entire flowering stage (Sánchez et al. 2014b). Although the expected mid and long-term scenarios of high temperatures are not recognize as a relevant risk by responses of farmer associations, they are already changing the rice growing calendar and introducing new varieties which are more tolerant to heat stress and longer cycle rice varieties (e.g. J-sendra 155 or Puntal 145).

In a qualitative way, the farmer associations responses reflected that farmers in the Doñana coastal wetland: (i) are likely more concerned about the present than about the future; (ii) are very aware of the damage of current climate extremes in rice production and the natural ecosystem, although they do not entirely recognise that the intensification of current extremes may be a consequence of the climate change; (iii) probably do not perceive increased climate variability as a risk to be concerned in the long-term, since they have a shot-term view more addressed to profit-driven principles than to those related to climate change; and (iv) are likely more concerned about severe droughts or salinity since they have faced these events over the years. Rice farmers have demonstrated to have good adaptation capacities to current and past extreme events, but they do not seem to be particularly open to innovation for the forthcoming risks linked to climate change.

Forming the second category, the respondents provided a broad spectrum of local adaptation options for the rice production to face the identified risk. We organize them into three main groups: technological, organizational and governance measures. The following categories are related to the current implementation level of the options, farmer associations and environmentalists' acceptability and administration support per option.

Different points of views about the adaptation options were stated depending on the type of participants. Almost half of adaptation options included in Table 3 confront farmer associations and environmentalists' views, since the options may not be fully corresponding to their own interests and goals. Farmer associations try to promote technological and governance measures that involve options to build new water infrastructures (e.g. a pipeline to bring in the water directly upstream from the salt water intrusion) or increase the water supply to the rice crops (e.g. water releases from upstream reservoirs or supplemental transfer water from the Guadiana new riverbed). So far, environmentalists and administration have null acceptance and support from those options that may result in higher economic costs and environmental impact of new infrastructures. In the perception of the farmer associations, measures that may imply lower yields (organic production, rice varieties adapted to climate change) or reductions of the cultivated area should not be accepted. However, Pulido-Calvo et al. (2012) results supported that the current water deficit in the Guadalquivir River Basin may inevitably lead to reductions in irrigated areas. Environmentalists agree with this projection, but the administration seems not willingness to support the change of management or activity.

Technological measures to increase water efficiency at the field level were most likely to be accepted for both farmer associations and environmentalists. For instance, water recirculation and reutilization within the paddy rice or increased technical efficiency of the irrigation systems. Other technological options that have already proven benefits to the rice production and are widely implemented in the area (laser levelling and integrated production) were also fully supported by the administration. Rice farming in the Doñana wetland is characterized to be a highly mechanized agricultural system with qualified labour that uses precision agricultural methods (Aguilar 2010; De Stefano et al. 2014).

Organizational measures related to water management were positively perceived by the farmer associations and environmentalists. Their responses reflected that there is a lack of local monitoring and information on water availability and use. The provision of accurate, accessible and useful water information at different scales is essential to deal with reductions in water availability (Wei et al. 2011). Reed et al. (2006) reported that including thresholds information about the risks at local scale, even when they are difficult to identify, they can further improve the value of monitoring in managed ecosystems. In the perceptions of the two groups, farmer associations and environmentalists, there is also a need of anticipating management options to local water shortages. Once problems have arisen, reactive management efforts can be more costly than anticipating management to reduce risk by actions to enhance the resilience of the river basin (Palmer et al. 2008). Proactive management efforts may include among others: management plans to the risk of water scarcity at the farm level, on-farm reservoirs, improvements in water use efficiency (Iglesias et al. 2007) and, the establishment of water markets to negotiate water between water users and in turn encouraging the reallocation of water rights to restore freshwater ecosystem health (Garrick et al. 2009; Rey et al. 2014). The high number of "no opinion" answers obtained within the category of "administration support" to technological or organizational options is striking. It suggests to some extent a limited commitment to measures addressed at farm or local scale on this topic. Most of questions concerning to governance options were perceived to be supported by the administration, since it directly fall in their scope of action.

Governance measures included options addressed to improve the coordination between institutions. The critical importance of institutional good governance has been previously established as a requirement for the regional

adaptation capacity by preceding research (Berrang-Ford et al. 2014; Hanak and Lund 2012; Iglesias 2009). Increase scientific research, farmer training and technical advice were governance options perceived positively by all the groups. Finally, a lack of confidence in the truth or efficacy of governance measures addressed to climate change strategies and environmental awareness is often referred in the farmer associations' responses. These results prove that climate change and environment can be concepts which are not be easily grasped, and tends to be something that is less tangible to farmers. Experts also pointed out the need of encouraging the farmers' long-term views by climate change advisement and capacity building.

Overall, the results from the consulting process stressed the difficult to find adaptation options which are concurrent for the farmer associations, environmentalists and administration preferences. The spectrum of potential adaptation options in the case study can be represent from two end points, the purely environmental one (eco-centric perspective addressed to reduce impacts on the Guadalquivir River resources and the conservation of natural ecosystems), and the fully agricultural (technocratic perspective addressed to ensure rice yields and productivity) (Figure 4). If possible, policy makers and researchers should try to encourage more flexible adaptation options or those located in the middle of the spectrum where environmental and agricultural profit-driven preferences are closer. The international competition in a globalized sector together with the new environmental requirements from CAP might bring more pressure, raising the current conflicts between water users in the area (De Stefano et al. 2014). The portfolio of adaptation options and initiatives will probably fail if policy makers and advisors do not empower and inform local actors (Jones 2010). Additionally, there is a need of adaptation options that in turn are able to mitigate climate change by having less favourable energy implications (Hanak and Lund 2012).

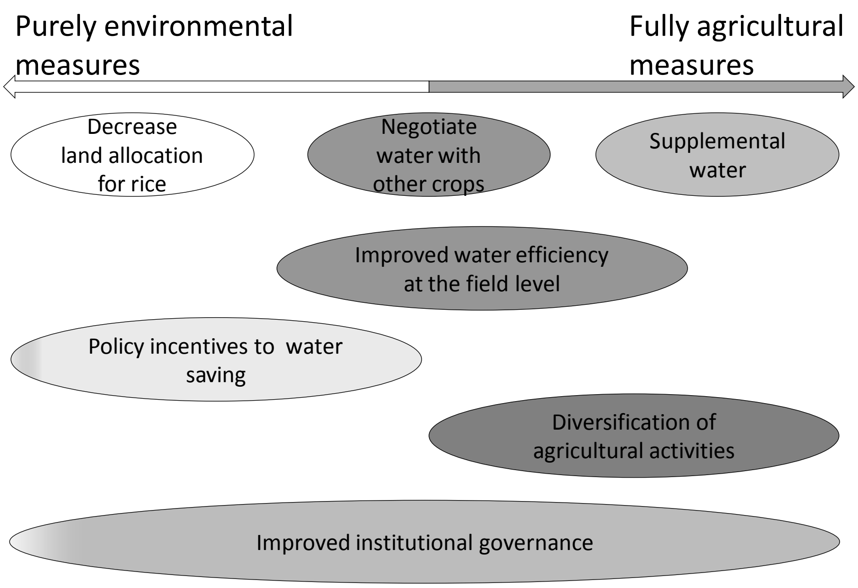


Figure 4. The spectrum of potential adaptation options to climate change for the case study

Potential policy interventions based on the interrelation of the two results

The interrelation of the qualitative and quantitative components of the study is a challenge. Our approach to interrelation is summarised in Table 4 and includes three steps. The first step is the characterisation of water shortages under climate change by the WAAPA model. This diagnostic step is a quantification of the potential water availability changes in the basin and in Doñana, in particular. The broader scale is necessary, since the changes at the local level - and the potential solutions - depend on the changes in the basin. The simulations of water availability changes in all sub-basins range from -45 to -93% of current water availability.

The second step explores the choices of stakeholders. The complete stakeholder views on adaptation measures are a consequence of their recurrent exposure to water limitations under the current climate. The range of options identified include agronomic, water management, and governance measures. The measures related to water management are then selected to provide an quantitative estimation on their effectiveness with the WAAPA model in the third step.

The approach links perceptions on the potential effect of the measure with a quantification by means of a water policy model. We focus on options that presented a high degree of disagreement among the stakeholders groups (Table 3). The application of the WAAPA model to these choices helped clarify the objective effect of the options. Furthermore, the WAAPA model was also used to simulate policy options that could be implemented in other sectors, e.g., urban or ecosystems, since these choices could bring a quantitative perspective to compare the local community choices.

The Adaptation Policy 1 addressed to improve water urban use could reach major improvements of water availability for irrigation and in turn avoid reduced water for environmental use by adaptation policy 2. The use of additional water infrastructure for irrigation (e.g. from hydropower reservoirs) was performed by the adaptation policy 3. The simulations showed that the effect for improving water availability of policy 3 was not significant. Adaptation options to improve the water managements by interconnections (a new pipeline connecting upstream water bodies to the rice fields, additional releases from upstream reservoirs or transfer of water) were endorsed into adaptation policy 4. The adoption of policy 4 was specially controversy between stakeholders in their acceptance, however the simulations clearly showed improvement of less than 20% except in a few sub-basins and scenarios.

Table 4. Integration of stakeholder choices and potential policy choices

Diagnostic water shortages from model WAAPA and stakeholder views First step	Choices of the stakeholders that can be simulated with WAAPA[1] Second step	Adaptation policy simulated with WAAPA[2] Third step	Quantitative evaluation of the effect on water availability[2]
Water	• Flexible actions at the	Adaptation policy 1	Overall the largest effect on

shortages simulated in all sub-basin ranging between -45 to -93% of current water availability	basin levels (trade-offs with environmental and urban efficiency options)	and Adaptation policy 2	water availability in most of sub-basins and scenarios
	• Use of additional water infrastructure for irrigation (hydropower reservoirs to be use also for irrigation)	Adaptation policy 3	Overall no effect for improving water availability except for very small positive effects in for only one climate change scenario
	• New pipeline connecting upstream water bodies to the rice fields • Additional releases from upstream reservoirs • Transfer of water	Adaptation policy 4	Overall improvement of projected impacts less than 20% except in a few sub-basins and scenarios

[1] Included here only the options that can be simulated by WAAPA mode, additional information presented in Table 3.
[2] Additional information and quantification in all sub-basins presented in Figure 3

Conclusions

Policy is deeply involved in the water sector. Usually, policy development is based on an historical analysis of water demand and supply. It is therefore a challenge to develop policies that respond to an uncertain future. Indeed, science-policy integration is one of the most complex challenges that the scientific and policy making communities face since it involves knowledge sharing and ex-change among a wide range of disciplines and actors (Quevauviller et al. 2005). Despite these challenges, it is possible to achieve this goal and there are success stories throughout the world.

In this study we have attempted to face part of this challenge by presenting an approach that assesses how people – water policy and local actors – may influence water in the costal wetland under climate change. Together – policy and stakeholder choices -- may be useful in singling out areas for moving towards adaptation and dialogue. This information may be used to implement and develop policy.

We recognise that the data needs for developing such a decision-making tool are complex and may be hard to satisfy; nevertheless, the conceptual steps that are presented remain valid and may be undertaken at a simplified level. Moreover, since the kinds of policy decisions being considered are at a local level it is likely that the availability of data will be greater.

Qualitative information from participatory research can be of great value in climate change adaptation and policy making when is combined with other tools or models to generate quantitative information (van Aalst et al. 2008). Recent researches have combined both methods to assess and identify climate change risk and adaptation options with valuable results on the adoption of a local adaptation strategy (Picketts et al. 2013; Cohen et al. 2006). Tisdell (2010) evaluated the implications of different water policy options in a semiarid area of Australia by modelling and found that the most cost effective option was a reduction of the water allocation to entitlement holders in order to increase water available for environmental use. Similarly to our study, Cohen et al. (2006) identified, by combining computer-based models and participatory research in the Okanagan Basin (Canada), a portfolio of adaptation

options for water resources management rather than seeking consensus on the "best" option or process. Méndez et al. (2012) explored the historical records of the Doñana case study to develop a tailored action research program and provide specific policy-relevant recommendations for water resources management and wetland conservation. They conclude that there is a need of flexible and adaptive institutional regimes, social research and public participation, and improved monitoring and mechanisms for information exchange among others, which seem to be quite concurrent with our findings. Palomo et al. (2011) also carried out a participative process to analyze the current and the future situation in the Doñana wetland. They stressed the scarcity of water as the biggest problem and proposed consensual management strategies that include coordinated local plans and increased professional training. Participatory research can help to advance adaptation planning since knowing and doing is linked through action (Moser and Elkstrom 2011; Picketts et al. 2013).

Climate change is a global challenge with increasing severe consequences at the local level. In the Lower Guadalquivir River Basin District, existing water conflicts between the rice farming and the natural ecosystem are expected to be intensified in the future due to projected scenarios of water availability reduction and higher temperatures. This study aims to identify flexible climate change adaptation options in the Doñana coastal wetlands by simulating water availability to farmers with the WAAPA model and by engaging informed stakeholders in the assessment process. The combination of both methodologies approaches the potential adaptation options to the local environmental, social and policy context.

Results suggest that perception on new water infrastructure and farming subsidies dominates the decision process. Information provided during the study shaped the final adaptation options developed. Our research contributes to the definition of sustainable water management for rice production, livelihood support and the environment.

Results from the consulting process showed how the accelerated state of climate change is already affecting the rice production and the natural ecosystem in the Doñana wetland and what are the main conflicts and agreements on adaptation options under water availability reductions. The water scarcity and the water quality deterioration were perceived by all the informants as the major risks for the good functioning of both the rice farming and the natural ecosystem. Rice farmers do not recognize higher temperatures as a risk to be concerned, but they are already changing the rice growing calendar and introducing new varieties which are more tolerant to heat stress. The rice farming is a highly mechanized and organized agricultural system and rice farmers have a high education level. However, they seem to have a shot-term view of risks and they do not necessarily link them to climate change. Reductions of water availability together with the large water need to irrigate the rice fields and to control the water salinity will raise the current conflict between water users from different economic activities and the natural ecosystem conservation.

There is a shared perception on the need of new and diverse local initiatives to face the increasing water scarcity and salinity risk. The decision making processes of adaptation options is variable according to the stakeholder views. Farmers Association decisions are mainly dominated by technological and profit-driven principles with preference on new water infrastructure and farming subsidies. The lack of generational renewal by the decreasing number of young farmers and the new environmental requirements from CAP can bring more pressure on local farmers' price support. Environmentalists showed reluctance to those options which may result in higher economic costs and environmental impacts due to new infrastructures. Environmentalists and administration actors supported the reduction of rice cultivated area as an effective adaptation option. All the actors and the experts emphasized the

important role that could play improved institutional governance and the need of encouraging the farmers' long-term views by climate change advisement and capacity building.

b) Participation in the Process Phases

(Please uncover the role of all participants in the process of implementing adaptation measures. The adaptation implementation has been divided into four phases for purposes of ease: 1) Initiative/decision to act, 2) Development of potential adaptation options, 3) Decision-making, and 4) Implementation. The process phases are to be filled out with information corresponding to each participant. I.e. if experts were not consulted in the 'decision-making' phase, then describe why they were not included. It is also important that a wide array of participants is described, including those that were excluded from parts of the process.)

Make a bullet point for each of the five participant categories below (and distinguish between for example different stakeholder or expert groups) and be as descriptive as possible how, why/why not were they involved.

Process phases:

Initiative/decision to act

- *Stakeholders*
- *Citizens*
- *Experts*

Politicians

Officials/legislators

Development of potential adaptation options

- *Stakeholders*
- *Citizens*
- *Experts*
- *Politicians*
- *Officials/legislators*

Decision-making

- *Stakeholders*

Citizens

Experts

• *Politicians*

• *Officials/legislators*

Implementation

• *Stakeholders*

• *Citizens*

Experts

• *Politicians*

• *Officials/legislators*

c) Participation Experience

(Please report with regards to your case study and the implementation of Participatory Methodologies using a traditional SWOT analysis – Strengths; Weaknesses; Opportunities and Threats)

Strengths	Weaknesses
Approach that assesses how people – water policy and local actors – may influence water in the costal wetland under climate change.	Although the three groups of participants selected are reasonably in line with adaptation in the case study, the interview sample is quite small and it is not necessarily representative of all the communities and organizations involved. The study did not address the full range of stakeholders which affect or are affected by climate change adaptation.

Opportunities	Threats
Qualitative information from participatory research can be of great value in climate change adaptation and policy making when is combined with other tools or models to generate quantitative information.	The accelerated state of climate change is already affecting the rice production and the natural ecosystem in the Doñana wetland and does not give time to the decision making process.

d) Learning through Participation

In order to capture how participation could improve the climate change adaptation process, please report with regards to your case study:

(a) Your view whether and how participation influenced the strategies and measures decided in your case?

(b) How you think the participatory process in your case could be/have been improved?

(c) Any novel (use of) participatory methods observed in the case studies

4. Climate Change Adaptation Measures and Strategies

a) Adaptation Measures under analysis in your case study

(Please identify your Adaptation Measures considered in this case-study and provide a short description of each)

Adaptation Measure(s):

1) Construction of a pipeline connecting the reservoir with the rice fields

2) Purchase of 20% of rice fields

Short description for each Adaptation Measure (Máx 50 words):

1) Construction of a pipeline connecting the reservoir with the rice fields

This measure ensures the supply of water to the rice fields in the current climate. It has a considerable impact on the environment and it does not consider the changes that will occur due to climate change.

It has an estimated cost of 150M€.

2) Purchase of 20% of rice fields

This measure would ensure the water supply for agriculture, environment and housing but have a high social cost in employment.

It has an estimated cost of 144M€.

b) Adaptation Measures selection and data availability prior to BASE

(Please describe how and why where these specific measures selected for further research and analysis under BASE and what is the baseline data already available for each specific adaptation measure. Máx 500 words)

c) Full description of Adaptation Measures

(Please provide a full description on each of the Adaptation Measures regarding these 21 leading questions under. If more than one Adaptation Measure please copy paste the structure provided.)

Process

I. Would, or at which part would, institutions and private stakeholders implement the measure autonomously to adapt to climate change (Adaptive capacity)?

(fillwithyouranswer)

II. Does the measure initiate further activities for adaptation to climate change? (Y/N)

If Yes, please name which

III. Does adaptation aim for flexibility and reflexivity (i.e. the ability to change as CC and other factors develop)?(Y/N)

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? (Y/N)

V. Is the adaptation measure iterative? (Y/N)

VI. Does the measure contribute to overall sustainable development, alleviate already existing problems and bring benefits for other social, environmental or economic objectives than adaptation (no regret measures)? (Y/N)

Please describe briefly how

(fillwithyouranswer)

VII. Can adjustments be made later if conditions change again or if changes are different from those expected today? (Y/N)

Outcome

Relevance and effectiveness of adaptation measures

VIII. How important is the climate change threat addressed by the measure? What economic values, ecosystem functions and socio-cultural values are at stake, and to what extent are they affected by climate change impacts? Is there an indication of overriding public interest, e.g. critical infrastructures, public health ?

(fillwithyouranswer)

IX. What portion of the targeted potential damages can be avoided by implementing the measure? (0-100%)

Efficiency

X. How high are the benefits of the measure relative to the costs? Are the costs justified by the benefits(Please refer to results of economic evaluation in chapter 5)

(fillwithyouranswer)

XI. What are the costs of the administrative implementation of the measure? Are there potential funding under the umbrella of other European policies(eg. CAP/Cohesion policy ?

(fillwithyouranswer)

XII. Does the measure give an incentive for innovation to different actors (e.g. SMEs) / can it deliver a competitive advantage for the local economy? (Y/N)

XIII. Does the measure have effects on employment? (Y/N)

XIV. How long is the time-lag between implementation of the adaptation measure and the effect of the measure? ______

XV. What is the timeframe during which the measure will have an effect? ______________________

XVI. Does the measure create synergies with mitigation (i.e. reduce GHG emissions or enhance GHG sequestration)? (Y/N)

XVII. Does the measure alleviate or exacerbate other environmental pressures? (Explain briefly)

(fillwithyouranswer)

Equity

XVIII. What are the impacts on different social or economic groups, are there expected impacts on particularly vulnerable groups? (distributional impact)

(fillwithyouranswer)

XIX. Does the measure enhance well-being and quality of life (e.g. in the urban environment)? (Y/N)

5. Impacts, Costs and Benefits of Adaptation measures

(This section of the CSLD follows the Economic Assessment Steps put forward by UFZ and thoroughly described in D4.1, chapter 4. Please check D4.1 for any doubts or questions. In case of duplication of information with previous sections of the CSLD feel free to copy paste.) For more detailed guidance (incl. two examples) please see the above mentioned chapter 4 of D4.1. Please do not hesitate to contact volker.meyer@ufz.de, oliver.gebhardt@ufz or Filipe Alves if you have questions about how to fill out this section.

Step 1 – Preliminary Risk Assessment and identification of adaptation tipping points

(max 1500 words)

(Some of these questions might be already answered in section 1 – if so, just copy&paste)

Water availability and potential policy choices

Climate change jeopardizes the equilibrium of water resources in the Guadalquivir water district and the impacts will vary as a result of local regulation capacity (Figure 5). The difference between runoff and water availability is defined by the effect of storage. Reservoir regulation is one of the most important water resources management policies in water-scarcity areas and has generated significant impacts. Existing reservoirs are being subjected to intense multi-objective demands on limited resources (i.e., water supply, flood control, hydropower, navigation, fish and wild life conservation, recreation, and water quality by assimilating waste effluents.)

These scenarios of water availability) demonstrate that in water scarcity regions, water availability is likely to be one of the great future challenges. Defining future water availability under different adaptation policy options is therefore a basic step for water policy formulation.

Reductions of water runoff and increased variability, resulting from exposure to climate change, will lead to significant decreases in the water availability. This clearly demands for adaptation policy measures. Here we only consider impositions of demand restrictions since regulatory capacity is already at a maximum in the river district. This is particularly true in the case of irrigation water demand scenarios since it is reasonable to assume that, without changes in policy, land use or technology, projected irrigation demand in the basin will be higher than present irrigation demand even if farmers apply efficient management practices and adjust cropping systems to the new climate. Moreover, when policy and technology remain constant, it has been shown that agricultural water demand will increase in all scenarios in the region (Iglesias et al., 2007, Iglesias 2009). The main drivers of this irrigation demand increase are the decrease in effective rainfall and increase in potential evapotranspiration (due to higher temperature and changes of other meteorological variables).

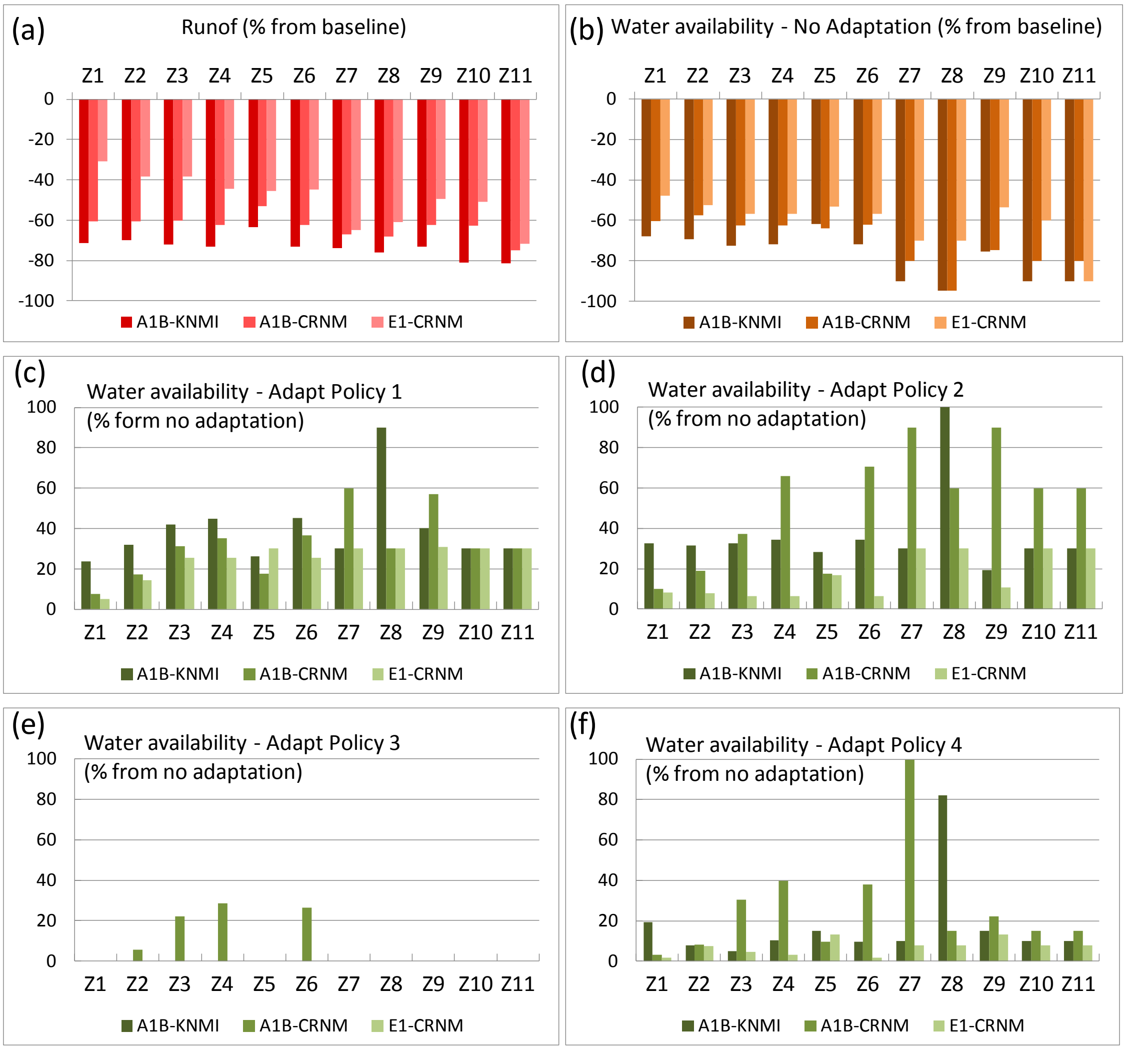


Figure 5. Effect of climate change scenario (2070-2100) with respect to control run (1960-1990) for the RCM models forced with two emission scenarios in the Guadalquivir water district. (a) Per unit reduction of runoff; (b) water availability for irrigation with current policy; (c) water availability for irrigation with improved water policy in urban areas; (d) water availability for irrigation with water reduced allocation for environmental uses; (e) water availability for irrigation with hydropower reservoir water conservations; (f) water availability for irrigation with improved the overall water management of the system by water interconnections.

What is the climate change related problem/risk you would like to reduce by adaptation?

- *Which problems already exist, what is/are the current risk/s?*
- *Which assets and sectors are at risk under current climate variability?*

• Which adaptation or protection measures are already in place? (refer to typology of measures in D6.1, table 2)

• How do these risks presumably change due to climate and socio-economic change?

• What are the main drivers, impacts and affected sectors (refer to BASE impact and sector categories, see also Table 1 of D6.1)

• Which climate and socio-economic scenarios are used?

Which adaptation tipping points can be identified?

• Can adaptation tipping points, critical levels for adaptation, be defined for this current strategy? (=when objectives are not met anymore due to changes)

Refer to otherwise expand on Table 3 of D6.1

• When (roughly) will these critical levels be reached due to climate change or socio-economic change

• Give appropriate period (2015-2030, 2030-2050, after 2050) for each considered combination of climate and socio-economic scenario.

Step 2 – Identification of Adaptation Measure and Adaptation Pathways

(max 1500 words)

(some of these questions might be already answered in section 4 – if so, just copy&paste)

What are the alternative adaptation measures?

• What are the primary and secondary objectives of adaptation?

What are the policy options for agricultural water management in view of climate change?

How can informed stakeholders contribute to better adaptation?

• What are potential measures to meet these objectives? (refer to typology of measures in D6.1, table 2)

1) Construction of a pipeline connecting the reservoir with the rice fields

2) Purchase of 20% of rice fields

• What is your baseline option (the "business-as-usual"-option)?

  • What is the ambition level of this baseline strategy?: Maintaining current risk levels or current protection levels (implying with CC risks may increase)?

There is a fragile equilibrium in the current situation that turn into a conflict in drought periods.

• *Is current backlog of investments for adaptation measures included or excluded?*

Included

• *Does it include only planned adaptation or also autonomous, non-planned adaptation?*

Includes autonomous adaptation

• *Are there complementary measures? Is it appropriate to bundle these measures?*

What are alternative adaptation pathways?

• *What is the "sell-by"-date of the measures or bundles of measures? I.e. when will they – under conditions of climate change – not any longer be able to meet the defined objectives?*

• *What would be alternative measures or bundles of measures at these "tipping points"?*

Step 3 - Evaluation Criteria and Method

(max 2000 words)

Step 3a Selection of evaluation criteria

Which evaluation criteria should be used?

• *What are the relevant positive and negative properties of the measures (costs and benefits) to be considered in the evaluation process (economic, ecological and social effects)? (see D4.1, chapter 4 for examples)*

Costs

O Implementation costs

O Market value of land

O Loss of economic activity

O Conflict with other users of the water district

O Environmental looses

Benefits:

O Environmental benefits

O Socio-economic benefits

• What is the appropriate unit to measure each of these criteria? Is the performance of the adaptation options measured in qualitative, monetary or other quantitative terms?

The performance of the adaptation options is measured in qualitative terms.

Step 3b Selection of evaluation method(s)

What is the appropriate evaluation method?

• Is it possible to express all relevant cost and benefit criteria in monetary terms?
(→ cost-benefit analysis)

• Is it possible to express the positive effect (objective) by a single non-monetary indicator?
(→ cost-effectiveness analysis)

As there are environmental costs and benefits the evaluation method will be cost-effectiveness analysis

• Are there several relevant criteria which cannot or cannot easily be expressed in monetary terms?
(→ multi-criteria analysis, PCBA)

Step 3c Weighting of evaluation criteria

(applicable only to multi-criteria analysis)

What are the preferences of stakeholders regarding the different evaluation criteria?

• Are there different stakeholder groups with varying preferences regarding the evaluation criteria?

Different stakeholders have strong differences in their preferences regarding evaluation criteria:

Rice farmers prioritize economic looses

Environmentalists prioritize ecologic looses

The Administration does not have a very clear preference.

• Which weight do stakeholders and/or decision makers attach to a substantial change in the performance of the adaptation options regarding each evaluation criterion?
(see D4.1, chapter 4.10.2 for guidance for the Swing-Weight method)

Step 4 - Data collection

(max 2000 words)

What are the costs and what are the benefits of the alternative adaptation options?

• *What potential data sources are available, including damage & impact assessment methods or existing CBA studies on adaptation measures?*

Ministry of Health, Water Quality Department, River Basin Authority, CEDEX (Centre for Hydrographic Studies).

• *If no relevant data sources are available and modelling cannot be undertaken: Which experts can estimate proxies for assessing the performance of measures regarding the respective criterion?*

• *How do the adaptation options perform with regard to each of the cost and benefit criteria selected in step 3a?*

What is the evaluation time frame?

• *What is the lifespan of the measure with the longest lifetime?*

The evaluation time frame is 90 years, 2010-2100.

Which discount rate should be applied?

• *Which discount rate is recommended by national guidelines for climate change adaptation measures (or public investments)?*

We give results for a 0%, 1%, 2%, 3% and 5% discount rate.

• *Is it a linear discount rate or any other type (i.e. declining, hyperbolic, etc.)*

We use a linear discounting over time.

(In addition, for testing the sensitivity of the results with regard to the discount rate(s) used, also apply a low and high discount rate (1% and 5%)).)

How to deal with data uncertainty?

• *Can uncertainties related to the performance of the measures regarding certain evaluation criteria be described by a range (min-max), a triangular distribution (min, most likely, max) or any other kind of probability distribution?*

Step 5 – Evaluation and Prioritization

(max 1500 words)

What is the ranking order of alternative adaptation options (measures, bundles of measures or pathways)?

• *For cost-benefit analysis:*
  What is the net-present value (discounted benefits – discounted costs) of the alternative options?
  What is the benefit-cost ratio?

• *For cost effectiveness analysis:*
  Which alternative achieves a defined objective at lowest costs?
  What is the cost-effectiveness ratio?

• *For multi-criteria analysis:*
  Which adaptation option performs best? (e.g. for PROMETHEE approach: which option has the highest net flow?)

• *What are the uncertainties associated with the performance of the different options?*

• *Is there and, if so, to what extent uncertainty in the ranking of options?*

• *Is it possible to determine which option most likely performs best or is it necessary to gather further information to reduce uncertainty (go back to step 4)?*

6. Implementation Analysis – Understanding, Leadership and Governance of the implementation of adaptation measures

The aim of this section is to establish whether adaptation measures can be implemented in the real world context of case studies, and what the key obstacles and opportunities are in doing so.

Please answer the following six questions giving specific evidence and examples where possible. In principle all implementation activities should be analysed, i.e. activities supported by BASE partners as well as those by other actors. If it is possible to inform about the implementation of those adaptation measures assessed for task 5.2, it is very important to do so in order to comply with the DoW.

Work in progress.

To ensure the answers provided are comprehensive and in line with WP2 and WP7, a checklist is provided below with the main factors that all case holders need to consider. Please read through this checklist and ensure you have discussed in your answers, all those factors that were in some way relevant to the implementation of your case study.

Questions

1. *How have climate change adaptation measures and strategies been advanced in the case study? Describe the process! (Minimum 500 words)*
2. *What drives the implementation process and who enables implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist and be specific about any relevant policies! (500 – 1000 words)*
3. *What obstacles were encountered to implement adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist and be specific about any relevant policies! (500 – 1000 words)*
4. *If any obstacles were overcome, how was this achieved? (Minimum 500 words)*
5. *What are the future prospects of the climate change adaptation activities in the case study? (200 – 500 words)*
6. *What is the key message from this case study (and which could work in other cases as well)? Don't forget to consider any specific policy recommendations that arise in your case study! (200 – 500 words)*

Checklist

When answering the above questions ensure you consider each factor listed in the checklist below that might have had a role to play in the implementation of your case study; please mark in the table what factors you have covered in your answers. The checklist might not be all-inclusive, so feel free to discuss other factors that might not be listed. Mark 0 – 5 (0 being not relevant and 5 being extremely relevant), or not applicable (N/A)

Checklist	
Specify sectors covered *(e.g. coast, city, agriculture)*	Agriculture
Specify adaptation measures covered*(e.g. altering cultivation practices, building defences; explain why they were chosen)*	Pipeline construction, Change of land use
Specify climate change impacts covered*(e.g. flooding, heat stress, sea level rise)*	Drought, increased salinity
Specify main results of activities *(e.g. changes, outputs)*	
Key factors influencing implementation:	**Mark as: 0 – 5, or N/A**
i. **Knowledge and information about climate adaptation**	5
ii. **Actors** (e.g. leadership, perceptions, understanding of climate adaptation, participation, decision making, stakes, conflicts/synergies)	5
iii. **Framing of climate adaptation** (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)	4
iv. **Local and regional context** (e.g. culture, history, geography, environment, economy)	4
v. **European, national, regional and local regulatory framework** (e.g. be specific about laws, strategies, policies)	3
vi. **Institutional context** (e.g. integration of adaptation into existing structures/activities/strategies, decision making, conflicts/synergies, governance arrangements, incentives for engagement)	3
vii. **Resources** (e.g. financial, human)	3
viii. **Nature of adaptation measures** (e.g. no regret, flexibility, important co-benefits, side-effects)	5
ix. **Other** (specify ______________________________)	

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