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Water Adaptive Management by Design and Practice

The case studies of Bolivia and Morocco

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by

GUIDO MINUCCI

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ABBREVIATIONS

ACCRA – African Climate Change Resilience Alliance
ADA - Agence de Développement de l'Agriculture
AM - Adaptive Management
ANAPQUI - Asociación Nacional de Productores de Quinua
ARPAIAMT - Asociacion Regional de Productores Agropecuarios Integral Ayllus del Municipio de Tomave
AUEA - Associations des Usagers de l'Eau Agricole
AWM - Adaptive Water Management
BMU - Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
CAF - Corporación Andina de Fomento Andean Development Corporation
CC – Climate Change
COMPASUR - Comité Técnico de Fortalecimiento al Complejo Quinua
CONACOPROQ - Comite nacional de Competividad y Productitividad de la Cadena de Quinua
COOPI - Cooperazione Internazionale
DEWS - Drought Early Warning Systems
DRR – Disaster Risk Reduction
ENSO - El Niño/La Niña–Southern Oscillation
FAO - The Food and Agriculture Organization
GDP - Gross domestic product
GIEWS - Global Information and Early Warning System on Food and Agriculture
GNI - Gross National Income
GRIVAC - Groupe de Recherche sur l'Impact, la Vulnerabilité et l'Adaptation au Changement Climatique au Maroc
GWP - Global Water Partnership
HEWS - Humanitarian Early Warning Service
IDMP - Integrated Drought Management Programme
IICA - Inter-American Institute for Cooperation on Agriculture
VMPS - Viceministerio de Agua Potable y Saneamiento Básico
IPCC - Intergovernmental Panel on Climate Change
IPGRI - International Plant Genetic Resources Institute

ISDR - International Strategy for Disaster Reduction

IUCN - International Union for Conservation of Nature

IWRM - Integrated Water Resources Management

MADREF - Ministère de l'Agriculture, du Développement Rural et des Eaux et Forêts

MAMVA Ministère de l'Agriculture et de la Mise en Valeur Agricole

MASEN – Moroccan Agency for Solar Energy

MDRyT - Ministerio de Desarrollo Rural y Tierras

MEA - Millennium Ecosystem Assessment

MENA - Middle East (Emirates) and North Africa

MIC - Manejo Integral de Cuencas

Ministerio de Medio Ambiente y Agua, (MEV)

Mw - Megawatts

NARS - National Environmental Information System

NDVI - Normalized Difference Vegetation Index

NGOs - Non-governmental organizations

OCC - Organizational Change Capacity

ONEP - Office National de l'Eau Potable

ONS - Observatoire National de la Sécheresse

ORMVAO - Office Régional de Mise en Valeur Agricole Ouarzazate

PACC - Projet d'Adaptation aux Changements Climatiques

PACT - Performance Acceleration Climate Tool

PNC - Plan Nacional de Cuencas

SEDERI - Directorios Departamentales de los Servicios Departamentales de Riego

SENAMHI - Servicio Nacional de Meteorología e Hidrología

SENARI - National Irrigation Service - Servicio Nacional de Riego,

SES – Socio-Ecological Servises

SNCCA - National Environmental Quality Control

SNEIA - National Environmental Impact Assessment

SOPPROQUI - Sociedad Provincial De Productores De Quinua

TIOC - Territorio Indigena Originario Campesino

UAB - Universidad Autonoma de Barcelona

UCER - Unit FAO Emergency and Rehabilitation

UNDP - United Nations Development Programme

UNEP - United Nations Environment Programme

UNICEF - United Nations Children's Fund

USAID - United States Agency for International Development

USD - United States dollar

VMEBC - Viceministerio de Medio Ambiente y Cambios Climáticos,

WFP - World Food Programme

WHO – World Health Organization

WMO - World Metereological Organization

WWF - World Wide Fund for Nature

ABSTRACT

Bolivia and Morocco have experienced extreme droughts within the past decade. Droughts of even greater intensity will likely increase in the coming years, and other stresses related to global market driven transformations and population growth will compound the effects of climate variability and change on water resources in these countries. The traditional water management is now considered inadequate to respond to uncertainties and extremes expected with climate change and other contextual conditions. As result, water management has shifted towards iterative and integrated management practices, more aligned with concepts of adaptive water management. This context of high uncertainty and high risks creates major challenges to water organisations, requiring the ability to adapt their routines to such changes and implement an adaptive water management.

A literature review has been carried out to identify the characteristics of adaptive capacity regarding organisations and institutions. On the base of this, a conceptual framework to assess organizational adaptive capacity has been developed by reframing such characteristics. The developed framework has been tested within two case studies, in detail the Municipality of Tomave (Bolivia) and the water basin authority of the Souss-Massa Draa (Morocco).

The study highlights how the incapacity to transform routines as the context is changing leads to the construction of barriers and to the inability of an organization to support the process of change of the society. In addition, the dissertation emphasis that the development of a working system based on cooperation requires first that an organization acquires skills and adapt its routines to the new working system. Furthermore, the development of a participatory process of planning and implementation of policies would help to reduce the trade-offs and conflicts related to water management. Linked to this, the development of a system for monitoring and evaluation of policies implemented organization can contribute to build an iterative mechanism so to allow a redefinition and improvement of such policies.

CHAPTER 1: INTRODUCTION

Water is a shared resource and its management needs to take into account a wide variety of conflicting interests. Water fulfils indeed various functions for very different usages and users. Therefore, water is valued differently by various groups of stakeholders. Furthermore, water is also dealt at different levels (multi-level) and by different actors (multi-actors) in the market, society and government. As long as water is abundant relative to its use, these interaction effects may not be noticeable. Moreover, natural water supply varies over time and some variability can be compensated by the buffering capacity inherent in the water system such as natural storage or adaptation in water use patterns. But in dry climate, or as water use and pollution rise, the externalities become problematic without institutional arrangements to clarify rights and responsibilities. In this context, thus, extreme events, such as droughts, putting a strain on competing uses have always been one of the major challenges for water management.

This dissertation focuses on water management in two drought-prone countries of the Global South, Bolivia and Morocco. It particularly emphasizes the role of adapting water organizations and processes to face drought impacts, which pose fundamental challenges to water policy makers as they imply complexity, scientific and political uncertainties.

In the late 1970s and early 1980s the message of new institutionalism was put to the forefront: that institutions in general and state institutions in particular are important for and make a difference to the collective choice processes (Ferragina et al., 2002). New institutionalists assume that administrative systems influence society and overall the environment, where relationships between citizens, private agents, and public organisations unfold. The new thinking on the importance of institutions has influenced thus a new policy agenda, including water policy. Throughout the 1980s and 1990s there was a growing concern that in many cases engineering-based projects had not been wholly successful, and that they had not often yielded the benefits that were expected. Increasingly, over the past decade, many programs in the water sector have begun to be primarily focused on developing institutional and human

capacity rather than physical infrastructure. The result of this trend has been an attempt by those working in the sector to understand the institutional aspects related to water management.

Nowadays, water systems [1] (Framing Committee, 2004) are increasingly challenged by the triple threat of a changing climate, rapid population growth, and competing demands for water. Competition among agriculture, industry and cities for limited water supplies is already constraining development efforts in many countries. Demand for water is increasing in order to satisfy the needs of a growing world population, for food production, energy, industrial and domestic uses and the environment. As populations expand and economies grow, the competition for limited supplies will intensify and so will conflicts among water users. The Intergovernmental Panel on Climate Change (IPCC) projects that changes in rainfall amounts, intensity and frequency in many parts of the world will continue to add to water-associated risks. Climate impacts on hydrology are set to include alterations in seasonality, a rise in the frequency or intensity of extreme hydrological events (drought or flood), higher variability of precipitation patterns and increased glacial melt leading to an amplification or reduction in run off (Matthews and Le Quesne, 2009; Bates et al., 2008). Moreover, a sense of lack of control is particularly pronounced in developing countries, where the capacities to understand the different issues of climate change as it affects the water systems are extremely limited among water managers. They are aware that they must cope with abnormal situations more frequently than they were used to, that the future is not likely to be similar to the past and that therefore they need guidance from the scientific community in dealing with the evolving situation (Mujumdar, 2013). The limitations of the ability to control extremes by technical means have become very clear during weather extremes occurring globally over the past years. Since 1990, EM-DAT CRED estimates that climate and hydrometereological disasters (droughts, extreme temperature, flood, mass movement of wet soil, storms, and wildfires) have cost the Latin America and the Caribbean over 100$ billion dollars, disrupting the lives of an average of 3,6 million people annually over that period (EM-DAT, 2013). Furthermore, in the first decade of the XXI century (2000-

[1] according to the definition given in the GWSP Science Plan.

2010), the number of disasters triggered by weather-related events (drought, flood, extreme temperature, storm and mass movement – wet) are the most frequent disaster types, outnumbering all other natural disasters combined, and accounting for over 87% of all natural disasters, with the widest impacts on people (UN/ISDR, 2011, p. 30). Moreover, within the same period, droughts, floods and storms combined affected the largest number of people (2300 million), resulting in total economic losses of USD722.3 billion, 72% of the total losses (Gopalakrishnan, 2013). Drought and flooding in particular can have devastating implications for rural populations dependent on livestock and agricultural production. Such events have triggered an increasing awareness of water managers for the possible challenges posed by global and climate change also because most recent forecasts suggest the likelihood of further worldwide increases in the intensity and frequency of water disasters in the years ahead. Therefore, the fragmented and sub-sectorial approaches are seen now as inadequate to address the increased use and abuse of fresh water systems associated with rapid social change taking place in most countries (Boutkan and Stikker, 2004, Cleaver and Toner, 2006, Cullet and Gupta, 2009, Kidd, 2009; McCay and Marsden, 2009). The need of coordinated management of water resources and of a system-wide approach is increasingly recognized, even tough it is not obvious as demonstrated by the everyday practice. The traditional centralized and technocratic approach is now considered inadequate to respond to uncertainties and extremes expected with climate change and other contextual conditions (Dominguez et al., 2011, Gersonious et al., 2012, Pahl-Wostl, 2007; Truffer et al., 2007). As result, the traditional hierarchical and technocratic focus of water management has shifted towards iterative and integrated management practices, more aligned with concepts of integrated water resources management and adaptive water management (GWP TAC, 2000; Pahl-Wostl, 2007). In response to nowadays challenge, water managers will need to adapt in a timely and effective manner, and in a way that builds resilience rather than degrades it. Resilience has defined by Folke et al. (2010) as "*the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity, that is, the capacity to change in order to maintain the same identity*". In this line, adaptiveness is increasingly

recognised as one of the central parameters for sustainable water management in rapidly changing physical and human environments (Pahl-Wostl 2007). It is worth to note even though it is not the object of this thesis that implementing an adaptive water management system to adopt a more sustainable model should envision also a critical review of the water usages, in particular in those areas prone to droughts or where the water resources is already scarse being under pressure due to the global market demands.

The complexity of water management and a rise in uncertainties linked to key drivers, actors, and boundary conditions would acquire approaches enabling management to adapt to changes in the system being managed (also see Gunderson and Holling, 2001). As Biswas and Tortajada (2010, p. 130) pointed out in an insightful paper, "*there have got to be radical changes in the governance processes and the institutions responsible for water to cope with the immediate challenges, potential future changes, and uncertainties both from within the sector and around the sector*". This context of high uncertainty and high stakes creates major challenges to water organisations. Thus they are required to respond within contexts of political and economic instability and to the upheavals brought about by natural disasters, na-techs and conflicts. To achieve this, organisations require the ability to observe and analyse their environment and expand the range of response options necessary to adjust not only to changes science can predict with some degree of confidence now, but also to those science has yet to identify. To do this successfully, organisations therefore need the capacity to continuously reflect critically and act effectively. Reforming organisational processes is a significant and costly task for organisations concerned, and even though the autor is aware of such issue, however this is not the objective of the present research. The main goal of this dissertation is to investigate the process through which adaptive capacity is operationalized by organizations in order to implement an adaptive water management to face future shocks (drought events) and stresses (environmental changes). Three broad research goals for making theoretical and methodological applicable advancements to the field of resilience studies are outlined here:

1. to characterize adaptive capacity, determining what attributes contribute most to build organisational adaptive capacity;

2. to characterize adaptive capacity understanding the dynamics and barriers surrounding the adoption of innovative management and organisational approaches.
3. to increase understanding of the barriers to the process of implementing an adaptive water governance and management;

Accomplishing these three goals will contribute to resilience thinking and sustainable science by refining and applying theory regarding the approaches that are more closely associated with higher adaptive capacity, and introduce novel conceptual framework to assess organizational adaptive capacity. Also, in this pursuit adaptive attributes that are most revelant for organisations and favour a proactive drought risk managemet will be identified and analysed. Furthermore, the findings should provide important baseline information to understand barriers to implement an adaptive water management and governance within the two case studied countries.

1.1 Research Background

The interest for working on drought and understanding more about this slow-onset phenomenon is grounded on some earlier working experiences. My first opportunity to work on this theme has been the Provincial drought risk Emergency Plan of the Varese Province in 2011 (Menoni et al., 2010). The area is commonly known as a zone rich in water, nevertheless from 2003 to 2007 various droughts events affected the Province. Two documents were developed: the emergency plan designed to be a useful tool to act and an integrative document describing the different factors of hazard and vulnerability as well as analyzing the reasons for water crises. What emerged from this study was that drought is not only an issue related to a reduction, delay or absence of rainfall/precipitation, but is also related to failures in water management.

The Varese experience made me reflect about the fact that failures may derive not only from technical problem, but also from the lack of negotiation capacity among different actors to establish agreements, cooperate, and share information. Moreover, utilities companies continue to operate according to

their routines and to apply a reactive approach without developing future scenarios and/or plans taking into account uncertainties to face a recurrent issue, such as drought.

Later on I had the chance to be involved in the EU-project ENSURE (www.ensureproject.eu) aiming at improving the understanding of the concept of vulnerability (i.e. physical, economic, cultural, social and systemic), at different spatial scales (regional and local), and to develop a method that integrates the assessment of different types of vulnerabilities. Within this project, drought was not tackled exclusively from an emergency perspective, but also in terms of medium and long-term impacts as well as actions to reduce vulnerability in the case study of the Northern Negev territory (Israel) (Parker and Tapsell, 2009). As the project highlights that the different types of vulnerabilities (physical, systemic, social, between systemic, social, economic, institutional and territorial) are not separated from one another, they actually influence each other. Such a complex interaction and interplay of vulnerability types named as "territorial" vulnerability within the Ensure project. The vulnerability of a region, a metropolitan area or an urban center is much more than just the sum of the vulnerabilities of individual objects. It has to do with the way regions, cities and their assets and facilities function, perform and are used by people, agencies and organizations. Furthermore, because water managers will likely face in terms of drought risk a worst scenario due to climate change effects, they show an interest shared with researchers to understand not only the magnitude of drought impacts and their consequences on water resources, but also what they can do to prevent, respond to, and adapt to these impacts.

Researchers anticipate drought preparedness measures that are likely to increase adaptive capacity; nonetheless there has been minimal testing of this and other assumptions about governance and institutional determinants of adaptive capacity at least in the Ensure project. These experiences fostered my personal curiosity/interest to understand the relationships between drought and water management and the role played by (water) institutions and organizations to foster adaptive capacity to face drought risk.

1.2 STRUCTURE OF THE THESIS

This dissertation is organized as follows:

Chapter 2 – Definition(s) and Impacts of Drought

In Chapter 2, I provide an overview of the literature relevant to the study aiming to convey an understanding of concept of drought, its impacts on ecosystem and humans and the forms to manage and monitor droughts as well as the current and main issues and challenges related to drought risk.

Chapter 3 – Water and Drought Management today

In this chapter I provide a synopsis of the current challenges of water management. I examine first responses to those challenges provided by drought management. Second I highlight the need to integrate drought and water management to face current and future issues. And finally, I analyse briefly the different classifications of the drought and water management measures and I propose a new categorization.

Chapter 4 – How water management and water organisations respond to today challenges?

The material positions the research in the context of existing knowledge. From this, the novelty which this research offers as a contribution to the domains considered is established. First, an overview of the pertinent domains is presented. Second, these are returned to in more depth in order to communicate a landscape of the subject areas, and to tease out significant issues and to present the locus of their correspondence to this research.

Chapter 5 – Research Methods

Chapter 5 provides an overview of the research methodology and reviews the decisions made about method and technique selection. It presents the criteria

used for the literature review, the background of the research and the way in which the case studies have been selected. It also describes the conceptual framework developed within this dissertation and tested in the two case studies to assess the organisational adaptive capacity. Finally, it introduces the criteria for the selection of research respondents in each of the two selected case studies as well as a thorough explanation of how these participants were identified, approached and selected. The aim of Chapter 5 is to demonstrate the solid foundation upon which relevant research decisions were made.

Chapter 6&7 – Case Studies

Chapter 6 and 7 apply the main arguments from Chapter 2, 3 and 4 to critically describe the case studies. In these chapters I use first survey data, interviews, and archival research to examine impacts of past droughts and recent environmental changes in the Draa Valley (Morocco) and the Municipality of Tomave (Potosí, Bolivia). Second, I use survey data, telephone interviews, and archival research to investigate the manner in which water institutions face droughts, climate change and their adaptivity to such (future). Furthermore, this chapter draws on qualitative data obtained by interviews and literature review to explain why certain approaches develop (or not) in relation to the water management.

Chapter 8 – Conclusion and Lessons Learnt

This chapter aims to first provide a summary of the principal insights derived as findings from the (open and semi-structured) interviews presented in the previous two chapters. Data and findings from the semi-structured interviews are summarized first and these findings are carried forward throughout this chapter. The aim of this chapter is to revisit relevant literature to discuss the overall findings and updated conceptual framework within a contemporary context. Also presented here are the implications of the findings and limitations of the study. By means of this approach clear contributions to knowledge this study has provided are further outlined and described and suggestions for

further research are made.

CHAPTER 2: DEFINITION(S) AND IMPACTS OF DROUGHT

2.1 DEFINITION OF DROUGHT

Droughts rank first among all natural hazards when measured in terms of the number of affected people (Obasi, 1994; Hewitt, 1997; Wilhite, 2000a). Although as a natural hazard, droughts differ from other natural hazards in several ways (Wilhite, 2000a). First, a drought is often referred to as a creeping phenomenon due to the fact that the onsets as well as the end of a drought are difficult to determine, the impacts of a drought increase slowly, often accumulate over a considerable period and may stay for years after termination. Second, in comparison to other disasters, droughts tend to affect spatially larger areas. Consequently, identification and quantification of impacts related to drought and the provision of relief are more difficult than for other natural hazards (Wilhite, 2000). Third, human activities can directly trigger a drought unlike other natural hazards, with exacerbating factors such as over farming, excessive irrigation, deforestation, over-exploitation of available water, and erosion, adversely impacting the ability of the land to capture and hold water (Mishra and Singh, 2010).

Thus, what drought is? A clear, universal and shared definition of what can be labeled as drought has not been achieved yet. Palmer (1965) wrote “drought means various things to various people depending on their specific interest. To the farmer drought means a shortage of moisture in the root zone of his crops. To the hydrologist, it suggests below average levels in the streams, lakes, reservoirs, and the like. To the economist, it means a shortage which affects the established economy”. According to this, thus, drought should not be considered only as a physical phenomenon. Rather, as stated by Wilhite (2002), drought results from the interplay between a natural event and the demand placed on water supply by human use.

Definitions can be divided in two classes: conceptual and operational definitions. The former state in relative terms (e.g., a drought is a long, dry period), while the latter aim to identify the onset, severity, and termination of drought periods. Some of the commonly used definitions are:

- The World Meteorological Organization (WMO, 1986) defines “drought means a sustained, extended deficiency in precipitation.”
- The UN Convention to Combat Drought and Desertification (UN Secretariat General, 1994) defines “drought means the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems.”
- The Food and Agriculture Organization (FAO, 1983) of the United Nations defines a drought hazard as ‘the percentage of years when crops fail from the lack of moisture.”
- The encyclopedia of climate and weather (Schneider, 1996) defines a drought as “an extended period – a season, a year, or several years – of deficient rainfall relative to the statistical multi-year mean for a region.”
- Gumbel (1963) defined a “drought as the smallest annual value of daily streamflow.”
- Palmer (1965) described a “drought as a significant deviation from the normal hydrologic conditions of an area.”
- Linseley et al. (1959) defined “drought as a sustained period of time without significant rainfall.”

However, drought definitions vary, depending on the variable used to describe the drought. Hence, drought definitions can be classified also according to other categories, which are discussed below.

2.2 Classification of drought

The droughts are generally classified into four categories (Wilhite and Glantz, 1985; American Meteorological Society, 2004), which include:

(i) Meteorological drought is defined as a lack of precipitation over a region for a period of time. Precipitation has been commonly used for meteorological drought analysis (Pinkeye, 1966; Santos, 1983; Chang, 1991; Eltahir, 1992). Considering drought as precipitation deficit with

respect to average values (Gibbs, 1975), several studies have analyzed droughts using monthly precipitation data. Other approaches analyze drought duration and intensity in relation to cumulative precipitation shortages (Chang and Kleopa, 1991; Estrela et al., 2000).

(ii) Hydrological drought is related to a period with inadequate surface and subsurface water resources for established water uses of a given water resources management system. Streamflow data have been widely applied for hydrologic drought analysis (Dracup et al., 1980; Sen, 1980; Zelenhasic and Salvai, 1987; Chang and Stenson, 1990; Frick et al., 1990; Mohan and Rangacharya, 1991; Clausen and Pearson, 1995). From regression analyzes relating droughts in streamflow to catchment properties, it is found that geology is one of the main factors influencing hydrological droughts (Zecharias and Brutsaert, 1988; Vogel and Kroll, 1992).

(iii) Agricultural drought, usually, refers to a period with declining soil moisture and consequent crop failure without any reference to surface water resources. A decline of soil moisture depends on several factors, which affect meteorological and hydrological droughts along with differences between actual evapotranspiration and potential evapotranspiration. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant and stage of growth, and the physical and biological properties of soil. Several drought indices, based on a combination of precipitation, temperature and soil moisture, have been derived to study agricultural droughts.

(iv) Socio-economic drought is associated with failure of water resources systems to meet water demands and thus associating droughts with supply of and demand for an economic good (water) (AMS, 2004). Socio-economic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply.

2.3 Drought in arid and semi-arid land

Drylands[2] cover more than 40% of earth land surface (Oldeman et al., 1990), hosting more than 2 billion inhabitants (Millennium Ecosystem Assessment, 2005). According to a ratio between precipitation (P) and potential evapo-transpiration (PET) these areas can be further subdivided into hyper-arid, arid, semi-arid and dry sub-humid zones. Such climatic zones are characterized by more frequent droughts comparing to other types of Earth lands. Moreover, such areas are under threat of desertification (Figure 1) excluding the hyper-arid zones mainly located in the Saharan Desert region, which have already reached the ultimate level of desertification.

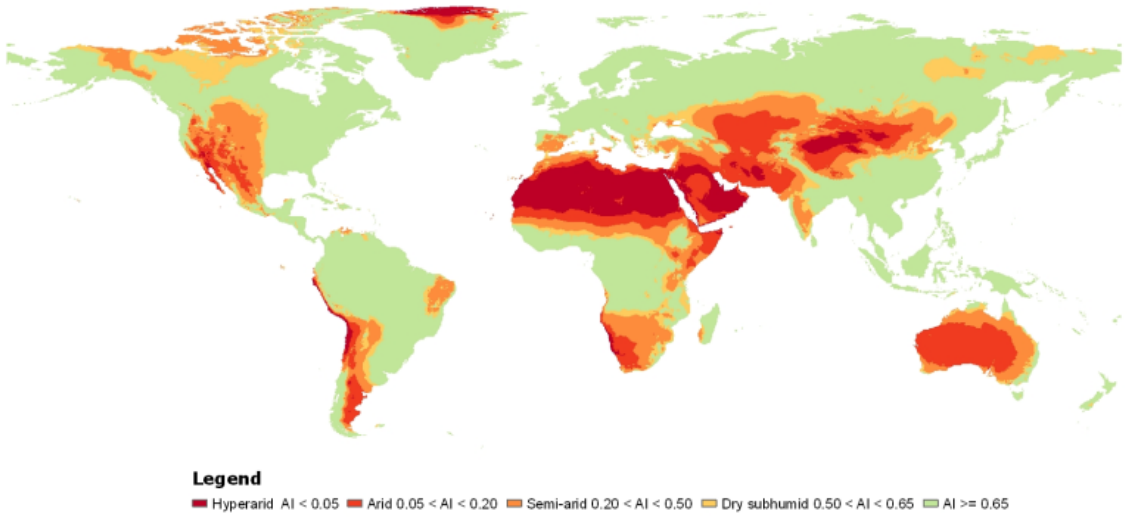

Figure 1: Global map of aridity. Source: FAO Geo-network. 2009. Available online at: http://www.fao,.org/geonetwork.

The probability of droughts increases usually with the rise in the ineffective rain-aridity proportion (Le Houérou, 1984). Further, an increase in temperature even though not followed by a decrease in precipitation may results in enhanced land degradation and reduction of productivity in the intense exploited lands (Emanuel et al., 1985; Manabe and Wetherald, 1986).

[2] UNEP, Millennium Ecosystem Assessment, 2005, Drylands Systems, Chapter 22 In Ecosystems and Human Wellbeing: Current State and Trends, Volume 1, Island Press.

In this thesis hyper-arid areas (less than 100 mm of precipitation per year), where the vegetation is extremely scattered, are ignored; contemporaneously it focuses instead on arid (100 - 200 mm) and semi-arid (200-400 mm) zones, which e.g. characterize the case studies areas. The former, arid, is in the South-East part of Morocco (Draa Valley), while the latter, semi-arid, is in the South-West of Bolivia (Tomave municipalities).

2.4 Drought and Desertification

In case of drought, ecosystems may get close to an unsustainable limit and their ability to rehabilitate is weakened partially or even irreversibly. The longer is the drought the most probable the transition beyond a sustainable state and toward a feedback-loop that can finally lead to desertification. With reference to this, ecosystem state shifts can cause large losses of ecological and economic resources, and restoring a desired state may necessitate drastic and costly intervention (Malek, 2000).

The desertification concept emerged during the first West African colonialism (Stebbing, 1935) and from the study of Sahel suffering and recovering from droughts. Desertification as it is claimed at the UN Desertification Conference in Nairobi, Kenya, in 1977, desertification is: "A reduction of the land production potential in arid, semi-arid and dry sub-humid zones that may ultimately lead to desert-like conditions" (see Karrar and Stiles, 1984). The notion was broadened at the Earth Summit, the UN conference on Environment and Development (UNCED, Agenda 21) in Rio Janeiro (1992) and agreed upon at the International Convention to Combat Desertification (ICCD, 1994): "Desertification means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climate variation and human activities".

Desertification is a synergistic climate and human land management influenced soil degradation process (Nicholson et al, 1998). In fact, as Spooner pointed out, desertification is a social (human induced) problem (Spooner, 1987); this is why at least one third of the present global deserts are man-made, and derive from

unsustainable lands uses (IUCN/UNEP/WWF, 1991). Inappropriate land usages by man are considered indeed as a cardinal factor accelerating or even determining desertification. In Africa, for example, the main anthropogenic effects are overgrazing following by agriculture and forest clearing (Le Houérou, 1996). Positive linear relation between the density of rural human population, livestock and desertification was found not only in Africa, but also in most developing countries (Le Houérou, 1996).

Whether frequent or infrequent, droughts exert a high burden on ecosystems. The vulnerability to droughts is reflected at the organism and community levels and at the entire ecosystem (biotic and abiotic). Mainly in fragile socio-ecological systems, humans command and control practices over ecological processes (Walker and Salt, 2006) can negatively affect ecological processes and resilience (intended as the robustness to withstand, and the capacity to recover from, crisis). Furthermore, the reduction in availability of some resources can lead society to increase the pressure over such resource because of autonomous unsustainable adaptations (Adger et al, 2011). Observations from dryland contexts confirm that ecological resilience reduces after each severe drought, especially if drought occurs simultaneously with population growths (Mainguet and Silva, 1998).

2.5 The Impacts of Drought on Ecosystems

During drought, extra clear days and consequent additional load of radiation affects a complex of abiotic and biotic processes in ecosystems. In this section we will focus on the consequences both direct and indirect of droughts on abiotic process.

Effects of droughts on biotic and abiotic components of the ecosystem

The proliferation of uncovered areas (microphytic patches) during drought has effects on an ecosystem water balance in two ways: by promoting runoff yield and by increasing evaporation. An example of the interaction between biotic

and a-biotic factors is the influence of drought on sand dunes and sandy landscapes. High surface temperatures during drought increase evaporation (of up to 1/3) (Gardner, 1950) and inhibit germination (Neilson, 1986). For sandy soils, elevated rates of erosion and/or deposition expose plant roots to high temperatures or alternatively bury the plants, resulting, in both cases, in high plant mortality (Weaver and Albertson, 1944; Herbel et al., 1972).

Increase in surface temperature and evaporation

Drought produces a direct increase in surface temperatures, especially of the bare areas. The outcome of the decrease of vegetation cover during drought period is in an increase in the extent of bare areas (Balling et al., 1998). The main feature of a bare area is to have a low soil organic matter (SOM) and a low microorganism population (Kieft et al., 1998; Borken et al., 1999). Moreover, future rainstorms characterized by intensive raindrop will have high impact in the bare areas. Consequently, storms would lead to higher surface compaction and to the formation of a physical crust (Le Houérou, 1996), which, in turn, promotes runoff (Cammeraat, 2004; Assouline and Mualem, 1997). As a result, relatively short drought of few years can cause extensive bare areas covered by microbiotic crusts. These areas would be characterized by increased runoff yields and high sediment and nutrient loss during future rainstorms (Kidron and Yair, 1997, 2001; Kieft et al., 1998; Bestelmeyer et al., 2006).

Wind erosion

Wind erosion is one of the main causes of sediment and nutrient loss during and after a drought period; the reduction in vegetal cover during droughts determines an intensification of the surface wind speed (Herbel et al., 1972) and hence, increased loss of soil nutrients (West et al., 1984). A side effect which could be considered positive related with stronger winds in bare areas is the reduction in fuel load and, thus, of fire risk and/or severity (Grover and Musick, 1990; Scholes and Archer, 1997; Peters et al., 2006). However, the higher temperatures that characterize drought years could increase the risk of fires.

The impact on fauna

Drought has a strong impact upon animals, both directly and through reduction in plant productivity. Two effects are the most relevant. First, the diminution of aboveground phytomass affects occurring the entire food chain while a drought is occurring. Consequently drought by impacting the vegetation affects diversity of the fauna and its composition (Noy-Meir, 1974) producing a migration of animals towards more favorable regions. Second, many animal species tend to postpone mating until the first substantial rainstorm. Besides this, many animal species are characterized by lower reproduction rate and higher mortality during droughts (Myers, 1968; Turner et al., 1970; Noy-Meir, 1974). Moreover direct decline of the amount of food, the reduced phytomass intensifications of competition over food between faunal species. This is mainly valid for species with a selected kind of plants in their diet.

The impact on flora

1. *Decrease in productivity and plant survival*

In dry ecosystems, productivity depends on rain supply (Patten, 1978) while plant communities are essentially sensitive to rain pulses (Noy-Meir, 1973). Drought imposes an additional burden plants and thus, to the entire ecosystem (Rietkerk et al. 2004), and may result in a reduction of aboveground phytomass. According to Le Houérou (1996), there is a linear relationship between the amount of rainy days and aridity. This is especially relevant for deserts where slight fluctuations may result in extreme dry conditions (Tevis, 1958) and thus in a substantial decrease in plant productivity. Rainfall amount is the most significant productivity factor explaining over 90% of the productivity variation (Sala et al., 1988). Nonetheless, to bypass the complex relations between season, altitude and other factors influencing R/P ratio and productivity, Beatley (1967, 1969) directly relates plant growth and soil moisture, and considers the top 7.5 cm soil layer as the most effective layer for plant survival. Higher soil moisture content and consequent higher plant cover may thus characterize elevated areas within the same geographic zone (Shreve, 1942; Svoray et al., 2004). Soil

moisture plays also a cardinal role in regulating plant growth thus following droughts seedling mortality may take place (Tielbörger and Kadmon, 1995).

2. Plant species coping capacity to droughts

Generally, plant species have developed physiological mechanisms to cope with variability in water supply. Annual plants balance low or even unavailability of water by inhibiting their growth until favourable moisture conditions are restored. Shrubs overcome dry conditions by reaching more moisture at greater depth. Halophyte species are able to use high soil water potential, while cyanobacteria shift into a dormant state (MacMahon and Schimpf, 1981; Gutschick and Snyder, 2006). Nevertheless, whether better adapted or less, drought results in a decreased aboveground phytomass.

2.6 The Socio-Economic Impacts of Drought

Direct and indirect influence of drought on humans

Among the drylands, drought effects on the ecosystem are strongest in the arid and semiarid zones. Drylands, arid and semiarid zones, host more than 2 billion inhabitants (Havstad and Schlesinger, 2006; Millennium Ecosystem Assessment, 2005). The social and economic effects of droughts are various and could be different according to the different development level of the country and thus to its particular level of social vulnerability (Figure 2).

Increasing temperatures and decreasing precipitation rates are expected in the near future (IPCC, 2007) to cause: potential losses of soil fertility (Mitchell et al., 1998); lower livestock productivity; dust storms affect air and water quality (Hagen and Woodruff, 1973; Stensland and Semorin, 1982), and are hazardous to aviation and traffic (Pye, 1987); alterations in pest and disease risks (Bar-Ziv and Goldberg, 1974), habitats changes and reduced availability of water in already water scarce regions (Schulz and Judex 2008).

Synergistic human actions have the power to potentially increase environmental

crisis, contributing to what can be seen as the socio-ecological deadline for life in dryland: landscape desertification. Furthermore, in fragile socio-ecological systems, humans command and control practices over ecological processes (Walker and Salt, 2006) can negatively affect ecological processes and resilience (for instance the robustness to withstand, and the capacity to recover from, crisis).

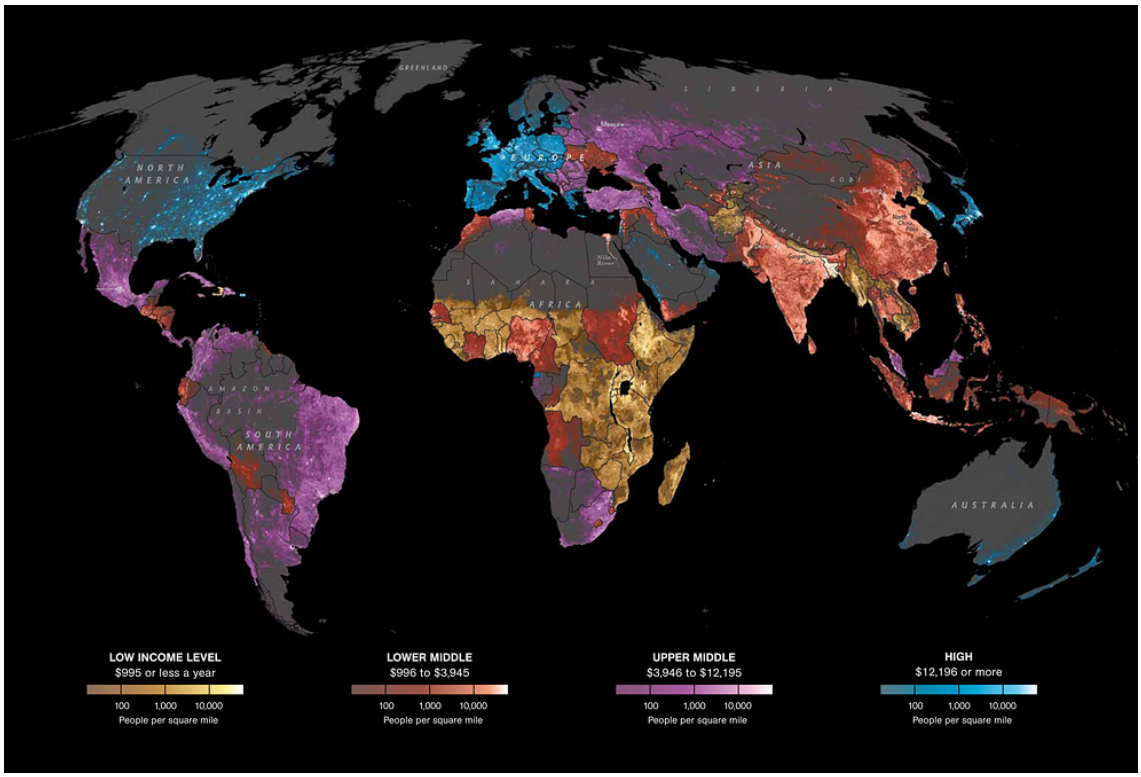

Figure 2: World income level. Source: "The World of Seven Billion" NationalGeographic.com, retrieved 6/29/11, http://ngm.nationalgeographic.com/2011/03/age-of-man/map-interactive

Furthermore, the reduction in availability of some resources can lead society to increase the pressure over such resource because of autonomous unsustainable adaptations (Adger et al., 2011). Observations from dryland contexts confirm that ecological resilience is reduced after each severe drought, especially if drought occurs simultaneously with population growths (Mainguet and Silva, 1998).

Agro-vulnerability to drought

The decrease of carrying capacity of grazed areas affected by droughts has as effect a reduction in the cattle productivity (Hille RisLambers et al., 2001) and thus both in substantial decrease in cattle heads (Conley et al., 1992) and sharp economic losses of cattle owners (Conley et al., 1992). Consequently, many breeders transfer the livestock outside the impacted zones (Gardner, 1950). While a drought is occurring, the cows are frequently replaced by goats that need lower amounts of food and are better adapted to consume shrubs (Lioubimtseva et al., 2005). As result of such switch to goat foraging on shrubs there is an increase of the cover of microphytic patches.

In the face of some advantages of nomadic farming during drought, the cattle farming are highly affected by drought events especially in the arid and semiarid zones. As a consequence livestock prices rise (Fafchamps and Gavian, 1997) and due to lack of natural vegetation, the emigration of farmers from the drought area (De Haan et al., 2002) is inevitable. Furthermore, if the frequency of drought is high it can lead to the migration of entire families (Le Houérou, 1996), modifing the balance of rural and urban populations, and impose drastic changes upon cities and infrastructure, as we will see in the case studies section. Moreover, droughts often result in a change in the farmed crops in favour of those demanding less water and more resilient to higher temperatures and drier conditions.

CHAPTER 3: WATER AND DROUGHT MANAGEMENT TODAY

3.1 WHAT ARE TODAY CHALLENGES OF WATER MANAGEMENT

Water management in a global change

Fresh water is a limited but shared resource first of all between the natural world and the humans with their different uses. With reference to humans' usages, water resources management needs to address the connections between resource and service, to provide the adequate water supply at the minimum cost, without endanger the environment and the future needs. This is extremely relevant because the effects of mismanagement are not straightway visible and can thus be overlooked.

With impacts on agriculture, education, energy, health, gender equity, and livelihood, water management regulates the most basic development challenges. Nevertheless, water management is nowadays challenged by global changes, such as population growth, urbanization, and industrialization, which are requiring nowadays more and more water while the over-exploitation and pollution of water resources are influencing negatively the state of water environment. Moreover, given the inextricable connections between land use and water management, integration between water management and planning policies is today extremely needed. Therefore, it is critical that water resource management systems take into account the implications of all development activities related to the environment and balance water resource management goals with long- and short-term development objectives. Water management should not be seen as a static concept, nor it should it be seen as an end in itself, but rather as a tool for equitable and sustainable social and economic development. For instance, the resolution of the General Assembly of the United Nations declaring access to water as a human right underlines the social and ethical role played by water management. Other issues, such as disparities in access to safe water, sanitation and water availability as a factor of development, are other challenges the water management has to respond to in the near future. Responding to those challenges implies the improvement of the political, social,

economic and administrative systems that are in place, and which directly or indirectly affect the use, development and management of water resources and the delivery of water service delivery at different levels of society. In other words, they demand an enhancement of the water governance.

Exposure and Vulnerability

Another challange refers to the rising exposure and vulnerability associated with water shortages because of increasing civil, industrial demands, but also due to the implications of the water used to produce the food required by the market. At global level, the amount of "virtual water" embodied in international food more than double in the period from 1986 to 2007 (Dalin et al., 2012). Moreover, water containing all sorts of fertilizers, pesticides, industrial waste, oils, metals and even radioactive waste, has radically compromised the ecological equilibrium of many surface and underground waters and they will continue to do it in other parts of the world. Furthermore, there is the issue of (legal and illegal) groundwater capitation and pollution, which is however weakly perceived, but that well show the results of a "development at all costs" model, which which today needs to be completely reviewed.

Drought risk and climate change

Water management has to deal with the fact that water varies in quantity and quality across the globe and through time. For instance, in arid and semi-arid countries, such as those analysed in this dissertation, Morocco and Bolivia, the management of scarse water resources is a major challenge. the Millennium Ecosystem Assessment (MEA, 2005) emphasised that 2 billion people living in arid, semi-arid and sub-humid regions are already today highly vulnerable to the loss of ecosystem services including water supply and that climate change is likely to increase water scarcity in these regions that are already under water stress. With reference to this, drought events can cause an intensification of the conflicts among competitive users of water in arid and semi-arid countries. In

addition, global changes are likely to increase the vulnerability of many regions to water scarcity and drought. In turn, drought risk is expected to increase in frequency and magnitude as result of the expected changes in climate that could produce a change in the seasonal distribution, and in a higher variability of precipitation patterns (IPCC, 2007). Drought and more in general water-related disasters can cause (large) direct economic damages, especially in rainfed and irrigated agriculture and in municipal and industrial supply sector, with severe consequences on economy, health, and social well-being. Moreover, the quality of water worsens during and soon after drought episodes, due to higher concentration of contaminants in all water bodies and to increasing seawater intrusion in coastal acquifers caused by the over-explitation of groundwater.

During a period of drought, water managers and the human society have to adapt and face water scarsity. The conventional water management approaches to prepare for drought conditions have proved to be inadequante since they were established during and for period of water abundance (Bazza, 2002). Furthermore, the lack of a definition of drought together with the randomness of drought crises made organisations involved in water management less attentive to planning for drought. Besides this, the lack of information about the cost of such natural disaster coupled with the rapid decrease of public interests in droughts in normal precipitation periods make drought and its determination of drought losses (generally distributed over longer time periods respect to other natural hazards) less urgent (Parker, 2013). Therefore, now that water resources are becoming scarce and drought periods more frequent, the conventional water management approaches need to be reviewed and adapted to drought (and water scarcity) conditions as they are no longer valid. Hence, on the one hand, it is necessaty to manage the water resource in a manner that takes into account the dynamic nature of social-ecological systems (SESs), the uncertainty related to climate change. On the other hand, the need to acknowledge the complexity of the systems to be managed and the limits in predicting and controlling them stress the necessity to adopt an adaptive water management as final goal in the development of water resources management policies.

Moreover, it is worth noting that water managers should foster region-specific

adaptation strategies with the local population, allowing site-specific expert knowledge to be incorporated into the planning process in order to: a. build a more participative approach; b. ensure that response strategies consider local social and political drivers. In addition, high complexity and various uncertainties characterize the relation between water management and climate change; therefore, water-resource management should be based on a broad perspective; second, it should include interests of different sectors; and finally, it should adapt a more advanced approach to account far factors developing at different spatial and temporal scales.

Water management and water organisations

As it has been illustrated earlier in this section, the expected and current impacts of growing population, drought and climate change pose new challenges to water management and require water managers to change their perspectives on how to deal with water issues. However, adapting water organisations and their routines to cope with and face those problems is a significant challenge. Furthermore, even though improvement in technologies and changing customers' behaviours are also goals to be pursued. Technological and institutional panaceas were applied globally trying to solve water issues without critical reflection or monitoring of their appropriateness and the conditions necessary for their satisfactory performance (Pahl-Wostl, 2010). As a consequence, increasingly, attention is paid to the role of institutions and organizations in enabling adaptation and adaptive capacity, and a number of publications have specifically recommended that institutional and organizational structures be both a focus of further research, and a priority for building adaptive capacity (Berkes, 2007; Cash et al., 2006; Eakin, 2005; Leary et al., 2007; Reid and Vogel, 2006). However, as shown by a comprehensive study on organisations and climate change adaptation carried out for the World Bank (Agrawal, 2008), little research exists on how organisations facilitate or constrain adaptive capacity in practice (Biermann, 2009).

1. Drought management

The traditional governmental approach has been to react to drought (as well as to other natural disasters) by providing relief or emergency assistance to the affected areas. Although such reactive approach, commonly known as the hydro-illogical cycle (Figure 3) has been widely recognized as costly and ineffective, it is still widely applied (Wilhite, 1993; Hamdy, 2005). Moreover, it has resulted in worsening vulnerability because of self-reliance of organisations and a lack of coordination across institutions and sectors (Hayes et al., 2004). However, in the last years drought planning is moving from a crisis management to a risk management-based approach following the trail blazed by United States of America (Martin, 1991; Pirie et al., 2004) or South Africa and Australia (O'Meagher et al., 1998).

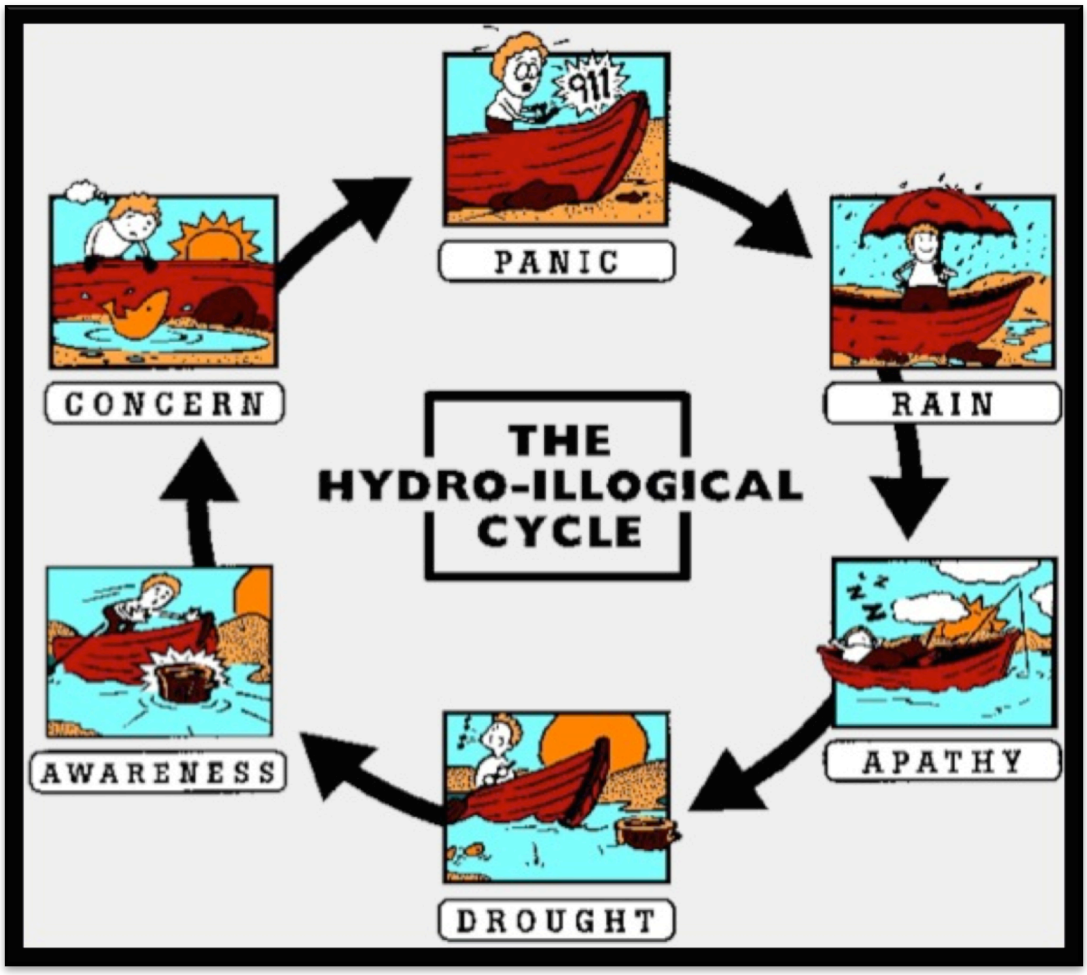

Figure 3: The Hydro-illogical cycle (source: The National Drought Mitigation Center)

Several initiatives have been undertaken indeed for establishing a common policy framework for drought management at the European level (i.e., Drought Management Plan Technical Report, the European Drought Observatory and the Policy Review of the Strategy for Water scarcity and Droughts) (Xerocore EU-project ((Drought Management and Policy Options (D. 5.2.), 2009). At a more global level, the World Metereological Organization (WMO) and the Global Water Partnership (GWP) are working in disseminating the concept of Integrated Drought Management Programme (IDMP), which aims "to support stakeholders at all levels by providing them with policy and management guidance through globally coordinated generation of scientific information and sharing best practices and knowledge for integrated drought management" (WMO and GWP, 2011). Whereas, the Global Drought Preparedness Network[3] promoted by the University of Nebraska provides the opportunity for nations and regions to share experiences and lessons learned (successes and failures) through a virtual network of regional networks. The same university hence fosters the 10-step Planning Process originally developed in 1991 and modified several times (Wilhite, 1991; Wilhite et al., 2000b; Wilhite et al., 2005), while it helps a large number of American states to develop a mitigation plan in order to be better prepared for future drought episodes. Sivakumar (2011) underlines that though more work is needed, globally the interest of natural hazards and water planners towards drought planning has increased in recent years. Drought planning indeed makes the conditions for identifing, investigating, and implementing in a systematic manner low-regret and/or cost-effective available strategies. It promotes thus a more informed decision-making process and the elaboration of efficient drought management programmes, which are often outlined in a drought plan (Gomez-Ramos, 2013).

[3] see www.enso.unl.edu/ndmc;
This network could provide its participants with critically needed information on drought policies, emergency response measures, mitigation actions, planning methodologies, stakeholder involvement, seasonal climate forecasts, early warning systems, automated weather networks, climate indices, impact assessment methodologies, demand reduction and water supply augmentation programs and technologies, and procedures for addressing environmental conflicts.

2. Towards an integration of drought and water management

By analysing adaptive and integrated water resources management models it is possible to find a strong relationship with the drought preparedness since they consider various principles required also for drought preparedness. These common principles can be summarized in flexibility, participation and deliberation among stakeholders, integration within various levels of institutional and actor/organizational networks, demand management (in equal or greater consideration as supply management). Furthermore, both models foster a shift toward a proactive approach to face unforeseen and future challenges and encourage the use of risk-based approaches to evaluate multiple potential future droughts (hazards in general) and water management scenarios in support of decision-making. Therefore, droughts are seen not only as a disaster but as a catalyst of change. A change that under the lights of many diverse pressures and challenges to consider in water supply and demand planning and management needs to be progressively implemented at all levels. As follows, bridging drought and water management seems to be a valuable strategy to respond to failures related to a separate management and with different time horizons of the same resource, water. However, there are still some open questions to be addressed.

First, decentralization of water resources management is essential for rapid drought monitoring and response implementation. Decentralization may produce chaos when there is no coherence between various levels (local, district, national) and no coordination between sectors. As pointed out by Wilhite (1991), Grigg and Vlachos (1993), Fontane and Frevert (1995), a correct definition of the roles and duties of the different levels of government in planning and co-ordination is a primary need in drought management process. In parallel with such explicit indication of roles, institutional flexibility should be ensured in order to maintain room for formal and informal partnership and cooperation, in particular during a possible future emergency phase.

Second, water management requires management capacity, including regulatory arrangements, financial instruments, standards and plans,

mechanisms for effective participation of stakeholders and knowledge and information systems. Furthermore, regulations as in the case of drought mitigation, but not only, should be established as part of the planning process and kept updated every time the reference contexts change. In the meantime, it is reasonable to assume that drought planning would be even more effective if it is incorporated into other resource and hazard planning processes, such as land- and water-use planning, agricultural and environmental policy.

In the European context, for instance, the Water Framework Directive (WFD) considers droughts in different parts and provides some criteria to consider drought impacts in the status of water bodies, for instance, using supplementary tools to the River Basin Management Plans (RBMPs) with detailed programmes and plans to deal with particular aspects of water management (Water Framework Directive Article 13.5). Nonetheless, Member States are facing some challenges in the application of these criteria; in particular, there is no clear detailed common definition of prolonged drought described in the Drought Management Report of the European Commission (2007), just a general common understanding (Estrela and Vargas, 2012). In addition, the relationship between RBMPs and Drought Management Plans tools is still unclear and to be defined (Estrela and Vargas, 2012). Besides, a change in available information and knowledge system would be necessary as well. Information would be provided to managers in a manner that clarify what are the uncertainties. In the meantime information has to be framed in terms of risk to the system(s), which managers are in charge of. There is a significant need for "integrated and adaptive decision support systems able to explicitly account for system uncertainty" (NRC, 2005). Such systems incorporate institutional, political, and economic considerations and translate physical science findings into relevant information for specific types of decisions within specific sectors. It is important to invest in integrating prediction with institutional decision processes to provide true decision support (Parker, 2013).

And finally, the development and management of infrastructure for annual and multi-year flow regulation, for floods and droughts, for multi-purpose storage, and for water quality and source protection are necessary. Although the

construction and implementation of such monitoring systems infrastructures represent a step further to face problems related with water, they acquire relevance only once they become resources, tools for decision makers. Monitoring systems should allow decision-makers to follow the development of drought before it becomes evident, to make the right decision regarding its onset and the type of mitigation measures to be launched (Bazza, 2002). However, because such links between monitoring systems and decision-making process are not so easy to develop, earlier agreements between institutions having different roles in the decision-making process are necessary as well as pre-established linkages between different levels of the indices (triggers) with drought mitigation measures. As suggested by Dziegielewski (2001), the core of a contingency plan is a determination of which drought response actions will be applied under what conditions of water shortage.
Different measures can be taken before or at the beginning of drought to help reduce its impacts.

Drought Early Warning Systems

It is often possible to provide early warning of an emerging drought due to the characteristics of such natural hazard. Notwithstanding, a survey carried out by the ISDR Platform for the Promotion of Early Warning shows that drought early warning systems are more complex due to different types of droughts and to the related defining parameters (Wilhite, 2002) than those for other hydro-meteorological hazards and are consequently, relatively less developed globally (UNISDR, 2007; UNEP, 2012).

In the Hyogo Framework for action 2005-2015, which is the roadmap negotiated by governments at the World Conference on Disaster Reduction in Kobe, Japan in 2005, Early Warning Systems are considered as the second priority for Disaster Risk Reduction (DRR). However, as illustrated by the UNEP (2012) report “Early Warning Systems: A State of the Art Analysis and Future Directions”, only a few Drought Early Warning Systems (DEWS) exist worldwide. Currently, three main systems are operating on a global scale and provide information on major drought events: the Humanitarian Early Warning

Service (HEWS) by the World Food Programme (WFP), the Benfield Hazard Research Center of the University College London and the Global Information and Early Warning System on Food and Agriculture (GIEWS) by FAO. The main aim of such warning tool is basically to provide in time relevant information regarding the emergence or probability of occurrence and the likely severity of drought to end-users and decision-makers in order to favour an effective response (UNISDR, 2006; Quansah et al., 2010). Augmenting forecast and early warning information with decision support capabilities to provide information on options for reducing vulnerability to drought enhances local coping capacities and provides an important mechanism for reducing drought risk.

Promoting the inclusion of indigenous or local groups and knowledge in drought monitoring and early warning systems is essential for developing appropriate local drought indicators, verifying the occurrence of drought, and communicating the warnings to local populations. Furthermore, though all types of droughts are due to a precipitation deficiency, it is not sufficient to rely exclusively on this meteorological factor to evaluate drought severity and subsequent impacts.

Effective DEWS must combine rainfall and other climatic parameters with water information such as stream flow, groundwater levels, reservoir and lake levels, and soil moisture into a comprehensive assessment of present and future drought and water supply conditions; to be effective a warning should be timely and reliable (Wai Leong and Wu, 2010) as to allow people in charge to disseminate the warning and feel confident about it (Buchanan-Smith, 2000). Although it is sure that a timely action guarantees a reduction in loss of life and property damage, false and missed alerts, have their own costs and decision-makers should be aware of this. However, a lack of awareness about availability and usefulness with reference to the actual formats of information provided can be seen among end-users (Kallis, 2008). It is important not to forget that the final and main aim of an early warming system is to inform people thus the design and the delivery strategy of the information should be carefully designed. Thus, the EWS process should be understood in the context of an integrated and holistic risk management framework (Asch, 2009).

Mitigation and response

Several classifications of drought mitigation measures are available in literature. Yvevjevich et al. (1983) classified the different measures distinguishing three main categories: (a) increasing water supply; (b) reducing water demand; and (c) minimizing drought impacts. Other classifications differentiate mitigation measures in relation to timing and thus in short- and long-term actions, programs, or policies implemented during or in advance of drought that reduce the degree of risk to human file, property, and productive capacity (Dziegielewski, 2000).

The CONHAZ project funded by the EU 7th Framework Programme and ended up at the beginning of 2012 classified the different measures following these categories: (1) Risk management and adaptation plans; (5) Communication; (6) Monitoring and early warning; (7) Emergency response; (8) Financial incentives and; (9) risk transfer. Following the idea to link basin drought status and management actions to take, Garrote et al. (2007) developed a methodology to link operational drought indicators to policy management actions in regulated water supply systems in the Tagus River Basin Drought Management Plan in Spain.

Rossi et al. (2005) proposed a methodology to assess different measures on the basis of their economic, environmental, and social impacts. Preferred measures are selected depending on both the scores of each alternative with respect to the selected criteria and on the capability to reach consensus among stakeholders. In contrast to mitigation, response actions are those taken once an area is experiencing severe drought and are intended to address impacts and expedite recovery of the affected area.

On the basis of the classification of Yvevjevich et al. (1983) and in line with the idea to integrate drought measures and water management I propose here a classification of mitigation measures in three main categories: (1) water supply management; (2) water demand management and; (3) water allocation and planning (Table 1).

The first category is water supply management, which aims at increasing the

amount of water available to users while protecting water resources, water-dependent natural systems and interrelated habitats. This category is composed by:

Reclamation of wastewater, which is any water that has been adversely affected in quality by anthropogenic, has two benefits. The first is pollution abatement. The second is source substitution. Treated wastewater can be reused as drinking water, in industry, and in agriculture (as shown by Jordan and Israel) natural ecosystems (Florida's Everglades[4]).

Rainwater harvesting refers to the direct capture of rainfall[5]. Linked to this, there is the fog harvesting techniques. Fog collection implies the collection of water from fog using fog fences, which are composed by large rectangular of canvas aiming at condensing fog into droplets of water and flow down towards a trough below the canvas[6].

Artificial recharge is the process through which the ground water is augmented at a rate much higher than those under natural condition of replenishment[7].

Green water indicates the precipitation on land that does not run off or recharge the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation[8].

Water transfers are used to shift water surpluses generated in one part of the system to another part in need of additional water supplies.

Desalinition may refer to desalination of brackish water[9] as well as of seawater. It means removing some amount of salt and and other minerals from saline water.

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[4] See http://www.evergladesplan.org/pm/projects/proj_37_wastewater_pilot.aspx
[5] The city of Berlin (Germany) is a relevant example of such technic; see also Schmidt et., 2007
[6] see: http://www.oas.org/usde/publications/Unit/oea59e/ch12.htm
[7] for further readings see: http://water.usgs.gov/ogw/artificial_recharge.html
[8] see Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M. and Mekonnen, M.M., 2011, The water footprint assessment manual: Setting the global standard, Earthscan, London, UK.
[9] Such system is extenively used in Egypt, see Talaat et al., 2002, The potential role of brackish water desalination within the Egyptian water supply matrix, Desalination 152, pp. 375-382

The second category concerns the water demand management, which involves the adoption of policies or investment to achieve efficient water use by all members of the community (Butlerand Fayyaz 2006). This category is composed by:

Seeking to improve irrigation efficiency targets to maximase water use, for instance, a well-know technique in the agriculture sector is the drop-by-drop system. In this system water falls drop by drop just at the position of roots. Furthermore, in distribution network systems reaching excessive percentage of water losses, leak detection and repair will permit to deliver and sold a higher amount of water produced.

Raising public awareness for water saving behaviour is essential in order to support conservation programmes. Public information campaings are carried out through advertisements or target marketing[10]. Linked to this, there is the introduction of water saving devices in households[11], of which low-flush toilets and dual flush toilets are probably the most well-known devices.

Water metering and water pricing are for example two economic measures that can improve water conservation and demand. A further step, it is represented by the introduction of rules that specify the minimum standards for constructed objects oriented to saving water[12].

Water restriction limit certain uses of water for example irrigation of lawns, car washing, filling swimming pools, or hosing down pavement areas. Water rationing determines commonly temporary suspension of water supply, or a decrease of pressure below that needed for adequate supply under normal conditions. Rationing is correlated with equitable delivery of critically limited water supplies in a manner that guarantee sufficient water is supplied to preserve public healthy and safty (European Climate Adaptation Platform,

[10] for further readings about results of public campaings see Keeney et al., 2008, Residential water demand management: Lessons from Aurora, Colorado, Journal of the American Water Resources Association 44(1), pp. 197-207

[11] regarding this, a really interesting Project is carried out by the Singapore's national water agency, see at:
http://www.pub.gov.sg/conserve/Households/Pages/WaterEfficientHomesProgram.aspx

[12] for instance, a change in the Building code has been issued in 2009 by the Department of Building Inspection of San Francisco in order to expand the water conservation requirements. see: http://www.sfdbi.org

2013)[13].

The third category is about water allocation and planning. Water allocation and planning focus both on future needs, conditions of this resource, and on how to guarantee sufficient amount of water for all demands.

The environmental flow as included in "The Brisbane Declaration" (2007)[14] describes the quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems'. According to this, the definition of the environmental flow is necessary to reduce the impact of dams as well as to minimise the effect that abstractions, diversions, or additions of flow may have on rivers and streams without dams.

In water law domain, water right refers to the right of a user to use water from a water source, therefore, the water rights trades indicates the process of selling and buying water access entitlements. Water right trade can contribute to lower the pressure on water resources in water-scarse regions, or regions with predicted degraded quality or quanity in the context of climate change (Luo et al., 2003)

Catchment Abstraction Management Strategies permit to determine how much water is reliably available for abstraction on a catchment-by-catchment basis (Environment Agency, 2013). In addition, by taking into account the volume of water already licensed for abstraction and how much water the environment needs, it is possible to ascertain how much water is potentially available for further abstraction.

Early Warning Systems (EWS) providing information on emerging dangerouse circumstance are an useful tool for governaments to protect population and avaoid ot reduce impacts of natural disasters on infrastructure and buildings.

Drought management plans aims to provide a management program of appropriate responses to drought conditions in the event water deliveries are

[13] see: http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=665

[14] see: http://www.watercentre.org/news/declaration

reduced or curtailed to treatment plants, resulting in a reduction to water deliveries.

Measures	Water supply management	Water demand management	Water allocation and planning
Waste water re-use	✓		
Rainwater harvesting	✓		
Fog harvesting	✓		
Artificial groundwater recharge	✓		
Development of water infrastructure	✓		
Green water	✓		
Water transfers	✓		
Desalination	✓		
Improving irrigation efficiency		✓	
Leakage control and reduction of water distribution system		✓	
Raising public awareness for water saving behavior		✓	
Introducing water saving devices in households		✓	
Economic approaches to improved demand management		✓	
Water saving measures in building codes		✓	
Measures on water restrictions and consumption cuts		✓	
Determination of environmental flow			✓
Water rights trade			✓
Catchment Abstraction Management Strategies			✓
Drought management plans and emergency measures			✓
Forecasting, early warning, preparedness			✓

Table 1: Drought mitigation measures with reference to water management approach (source: Author)

CHAPTER 4: HOW WATER MANAGEMENT AND WATER ORGANISATIONS RESPOND TO TODAY CHALLENGES?

4.1 HOW IS THE WATER PARADIGM CHANGING?

Along the history, different water management approaches have been applied in order to respond to the challenges of water shortage according to a shared mindset of how water management should be undertaken, codified in practice, laws, technologies, etc. In more recent years there has been increased discussion and debate about a paradigm shift in water management (see Unesco, 2013; Younos, 2011; Pahl-Wostl, 2011). Today water resources management approaches around the world are changing significantly due to a change of perspective that is currently ongoing based on insight regarding, for example, climate change uncertainty, Millennium Development Goals, and polluters pay principle.

From traditional water management to demand management

Water management has a long history, going back to the attempts in prehistoric times in response to seasonal changes in water availability. Water management played a key role in the transition from hunting and gathering to farming, and became yet more important with the appearance of cities, industrial towns, and administrative centres. Over the centuries, indigenous and local communities developed numerous strategies to ensure long-term sustainability of water resources, which nowadays we refer to as “traditional water management”. Such methods are characterized by being socially accepted and oriented to a sustainable utilization and managemet of natural resources since they aim to integrate land and water management (as we will see in the Bolivian and Moroccan case studies).

Once the technological capacities arose, however, the traditional management strategies were not considered sufficient to satisfy the increasing water demand posed by a growing population, thus the water management approach changed

toward a supply-driven water management approach. According to this approach, water needs of communities have been seen as requirements that must be met. In this line, the water supply approach has been (and continue to be) grounded on technological progess and development of infrastructure to increase water supply. Therefore technological efforts have been put in place to satisfy communities' water demand through the construction of large works (structural measures), such as dams and dikes, control of water levels, and centralized top-down decision-making. The construction of all those infrastructures is aimed at guaranteeing people's access to water. However, environmental concerns about the impacts of those projects, the rising costs and the difficulties to cope with increasing water demand are the flip side of the coin and the reasons of the failure of this approach (Kampragou et al., 2011; White, 2006; Gleick, 2000). In addition, such approach would not meet those requirements defined by the introduction of the concept of sustainable water use and the related issues, such as quality management, environmental integrity, cost effectiveness introduced in the water agenda.

Later on the water demand management (WDM) was introduced with the aim to avoid problems related to eccessive water use or at least to cap water demand (Brandes and Maas, 2004). However, as argued by Brooks and Brandes (2011) WDM is subject to criticism by being grounded on an anthropocentric rather than an ecosystem perspective and focusing mainly on measures for short-term water use efficiency rather than on long-term ecological sustainability.

Along time, other several shifts (Figure 4) can be highlighted in water management approach due to: changes in life style and people migration towards urban centers; new water uses either as new kind of use, such as recreation, or new authorization for water abstraction and use; water quality and scarcity; effects of climate change on water resources.

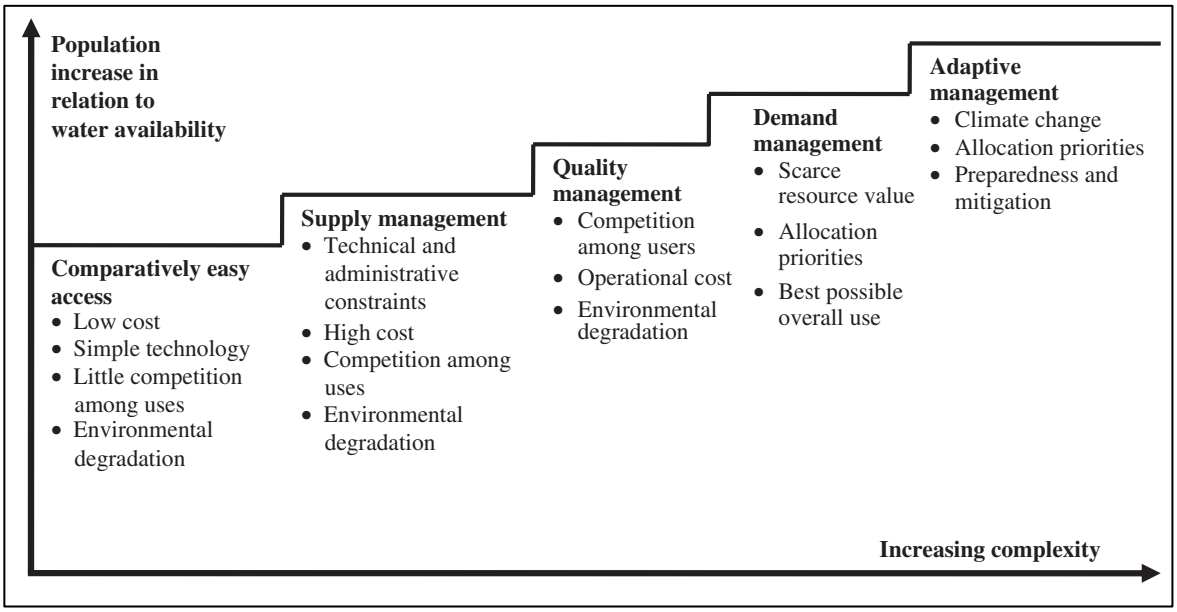

Figure 4: Management stages for an increasing demand – paradigm shifts (Adapted from: Kampragou et al., 2011)

A new water governance approach

For long time, water sector has been focused on increasing water supply without posing many efforts and spending much energy to explicitly address water challenges in a governance framework. Even though, technical and infrastructure development clearly has permitted a large number of people to access water, nowadays, as discussed in the previuos chapter, new challenges are posing together with the old and unsolved demands new questions. Within this context, a different form of governance is rising. This is well illustrated, for instance, by comparing one of the main conclusions of the National Science Foundation Drought Workshop held in Washington in 1990 "*drought response problems are water management problems"* with the oucoming conclusion of the GWP Framework for Action at the World Water Forum in The Hague in 2000, "*water crisis is often a crisis of governance*". As follows, the evolution in water management discourses from speaking of "government" to speaking of "governance" underline a radical change in thinking. Water governance is treated now as a prerequisite for managing water resources (Tropp, 2007).

Water governance is defined by the Global Water Partnership's (GWP) (Rogers and Hall, 2003, p.16) as "*the range of political, social, economic and*

administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society." The World Bank broadens this definition by including the process by which those in authority are selected, monitored, and replaced, and the effectiveness of government in implementing sound policies (Jayal, 1997).

When a governance system is established a platform is built for effective water management (Hoover, 2007). This platform provides managers with a set of policy objectives along with a set of important values and decision-making processes through which to achieve the objectives (Hoover, 2007). Thus, an effective governance system should enable practical water management tools to be implemented correctly (WWAP, 2003). In turn, Lautze et al. (2011) help clarify the difference between governance and adaptive management by stating that water governance is the process that contributes to decision-making and it is not the outcome of decision-making. Therefore, water governance is different from water management, and it should indicate institutions what activities should be enacted by water managers.

Scott (2001) in his article "Institutions and Organizations" identifies three main typologies of institutions: regulative, normative, and cultural-cognitive. Another distinction refers to formal and informal institutions. Formal and informal institutions pertaining to water influence both the governance and management of water resources. Throughout the decision-making process, water institutions are developed and implemented to manage water resources. Institutions such as a formal legislations inform people's behaviour and affects how the decision-making and management of water resources occur. Informal institutions, such as social codes of conduct, can inform people on what is acceptable behaviour in governing and managing water resources. In a community or household setting it is common to find informal rules that define people's behaviour and the nature of their relationships (Diaz et al., 2006). In other words, informal institutions suggest rules socially shared while formal ones indicate codes widely recognized and accepted as official (Helmke and Levitsky, 2004). Helmke and Levitsky (2004) underline the connection between formal and

informal institutions based on matching goals and effectiveness of formal institutions.

Della Sala (2001) suggests that the new rising form of governance advocates flexibility, which implies that informal institutions can be as important as formal ones. However, it is easy to imagine that institutional goals may be either compatible or conflicting. In the first case, formal institutions are effective and the goals fit within the formal and informal aims and thus institutions cooperate to achieve increasing efficiency and effectiveness of governance processes. In contrast to such ideal case, formal institutions are not be effective when the goals of formal and informal institutions are antagonist. Consequently, it is more likely that the governance regime would be characterized by a higher degree of corruption; less transparent decision processes and dominated by established power structures (Pahl-Wostl, 2009). This strongly contrasts with the idea of flexibility promoted by Della Sala and highlights the need to take the possible distinctions regarding the goals between formal and informal institutions into account to fully understand the nature of potential governance failures and drivers and barriers for change, identify drivers and barriers for change and the role of informality (Pahl-Wostl, 2009).

Effective water governance needs to support participation in the process for deciding how water is used; foster innovation and learning among stakeholders, and encourage adaptation to changes in water availability (Currie-Alder et al., 2006). In water management, direct action is taken with respect to water quantity and quality (Hoover et al., 2007; Ferragina et al., 2002) and decisions that affect society and the environment are required in an effective and timely manner (Hoover et al. 2007). Within the water sector thereby two water management systems are emerging: (1) the integrated water management and (2) the adaptive water management. Both develop alternative forms of organisations that can work within integrated and collaborative frameworks (Tropp, 2007).

Towards new water resource management

As a result of experiments done according to the leading concept related to each paradigm, numerous lessons have been learnt by water managers about the limits and opportunities of the different water management approaches in responding to change. For instance, a lesson learnt concerning water management approach that deals with different aspects of water sectorially, is that such approach will not lead to sustainable decisions, policies and programmes. The rising awareness of the complexity of environmental issues and of human-technology-environment systems has stimulated the development of new management approaches based on the insight that the systems to be managed are complex adaptive ones (Pahl-Wostl, 2002; Prato, 2003). Within this context, both integrated water resource management and adaptive management make claims about how best to organize knowledge production for sustainability in natural resource use under conditions of complexity—IWRM focusing on integration and coordination, AM focusing on handling uncertainty (Medema et al., 2008).

1. *The Integrated Water Resource Management Approach (IWRM)*

The Integrated Water Resource Management (IWRM) as defined by the Global Water Partnership (2000) is "*a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems"*. IWRM can be considered the operationalization of the Dublin Principles (1992) and it is based on three pillars, which can be summarised by: economic efficiency; ecological sustainability; and equity (GWP-TEC, 2004).

It involves an iterative process composed by a seven-step cycle (Figure 5). The promotion of coordination and integration is one of the main aims of IWRM to obtain a comprehensive water management and to enhance water resource sustainability (Braga, 2001). Although the aim or vision of such approach has been widely welcomed by those working in the water system, various authors have recently critized the way it has been implemented, claiming that the IWRM

approach, as defined by the Global Water Partnership, cannot be applied in practice because of operational constraints and difficulties in identifying measurable criteria of effectiveness (Jeffrey and Gearey, 2006; Lankford and Cour, 2005; Biwas, 2004).

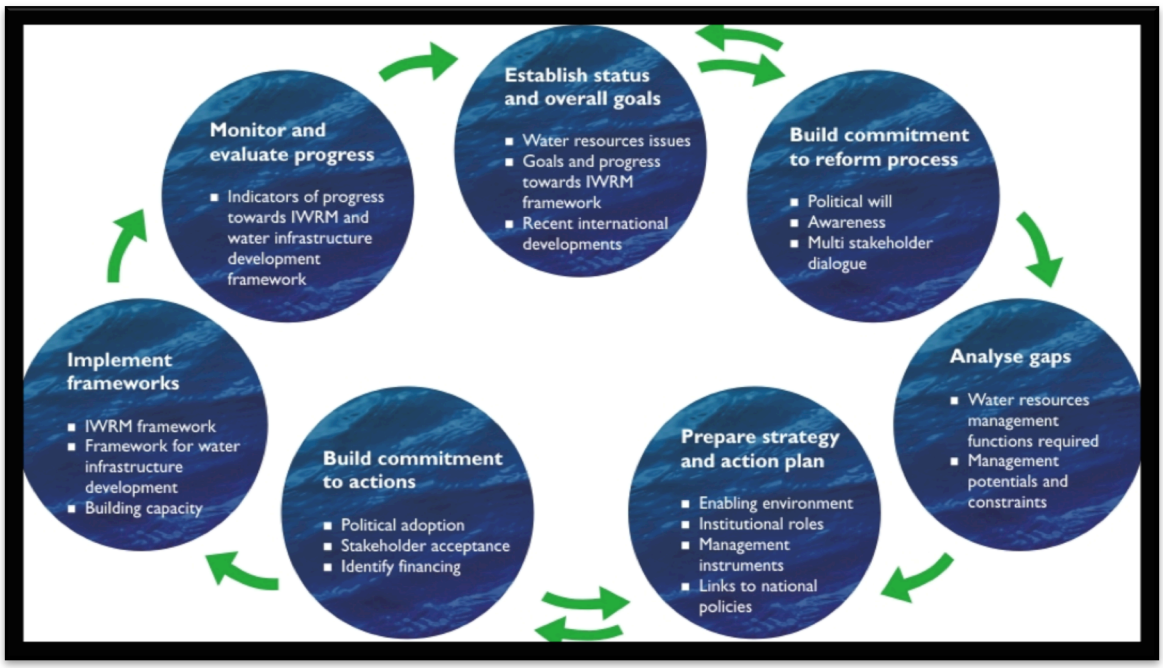

Figure 5: The IWRM Planning Cycle (www.gwp.org)

Molle (2008) describes IWRM as a "Nirvana concept" because even though valuable as a policy-framing discourse, it is in practice ambiguous, complex and contradictory (Conca, 2006; Biswas, 2004). Consequently, on the one hand, there is a relatively low level of agreement regarding what aspects should be integrated, how, by whom; on the other hand, some scholars (Biswas, 2004; Placht, 2007, Watson, et al., 2007) doubt that such integration can be achieved and argue that until now its impacts on improving water management has been marginal (Biswas, 2004). Moreover, the lack of an agreed definition generates ambiguity, fuzziness (van der Zaag, 2005) creating by itself a barrier to the implementation of this approach (Medema et al., 2008). As stated by Jonch-Clausen and Fugl (2001), it has become a buzzword characterized by multiple meanings.

Furthermore, the difficulties both in comparing and evaluating projects due to the lack of shared indicators (Petit and Baron, 2009; Biwas, 2008) and in

fostering a significant participation (Du Toit and Pollard, 2009) have been frequently underlined by scholars.

2. *The Adaptive Water Management (AWM)*

Despite the fact that IWRM approach has been extensively recognized as valuable in identifying the principal water management issues and the related conflicting interests (Pahl-Wostl, 2007a; Butterworth et al., 2010), many doubts have been raised regarding its effectiveness and feasibility (Pahl-Wostl, 2007a; Biswas, 2004). Consequently, more room has been dedicated to explore more flexible approaches, such as adaptive water management.

Adaptive Management[15] proposes a strategy for managing water resources through "*learning to manage by managing to learn*" (Bormann et al., 1999), fostering the use of planned actions as starting points for learning about systems' behaviour. The IWRM, instead, is basically a guiding principle for managing water resources by recognising the variety of uses to which water is put and the diversity of benefits water brings to communities and their environments. Therefore IWRM promotes a holistic approach to water resources management, the AWM guides the production of relevant knowledge to justify and scope intervention (Pahl-Wostl, 2007).

The NeWater[16] European project applied the theory of the adaptive management within the water management sector giving a broader definition of AM and considering it as a guiding paradigm to design adaptive policy process

[15] The idea of adaptive management (AM) is rooted and widely discussed in ecology and specifically in the work carried out by Holling at the end of the '70s (NRC, 2004). The AM concept was developed at the International Institute for Applied Systems Analysis in Vienna to support the management of natural resources under uncertainty (Holling, 1978; Walters, 1986; Walters and Holling, 1990; Prato, 2003; Ohlson, 1999). The adaptive concept is based on the idea of a limited capacity to predict future key drivers influencing both ecosystem and system behaviour and responses (Pahl-Wostl, 2007b) and is focused on learning and identifying uncertainties (Habron, 2003; Gunderson et al., 1995). Holling (1978) describes AM as an integrated, multidisciplinary and systematic approach to improve management and accommodate change by learning from the outcomes of management policies and practices'. Hence, adaptive policies are designed to test hypotheses about system response to human interventions (Lee, 1993).

[16] The NeWater project (New Approaches to Adaptive Water Management under Uncertainty) is an Integrated Project in the 6th Framework Programme of the European Union: www.newater.uni-osnabrueck.de

(NeWater 2007). Adaptive Water Management is defined witihin the project as "*an approach that addresses uncertainty and complexity by increasing and sustaining the capacity to learn while managing" (Mysiak et al., 2010).*

As stated by Bormann et al. (1999) an adaptive water management aims to interrupt the logic of the technology transfer in favour of valorisation of social learning and of knowledge sharing between managers, scientists and citizens. According to this, adaptive management is concerned with changing the way in which responsible authorities view and undertake management actions to focus on learning as a key way of dealing with uncertainty and promoting adaptivity (Medema et al, 2008). Hence, participation in decision-making process is viewed by AWM as an important prerequisite to sustainability (Sullivan, 2010) as well as for enhancing the quality of choices taken at each step (Shindler and Check, 1999). Furthermore, the AWM has as a target the enhancement of the adaptive capacity of the (water) system (Pahl-Wostl, 2007b), taking into account different kind of uncertainties while developing policies aimed at fostering change. In turn, recognizing the limited capacity of both predict the future and fully understand key drivers of ecosystems, management pratices are requiring to incorporate insights gained from past experiences (Pahl-Wostl, 2007c). Furthermore, adaptive management is not viewed as a tool to modify the system but to learn about it. Thus, to tackle the issue of how to increase the adaptive capacity of the system, it is necessary to understand what are the vulnerabilities and what determines the ability of a water system to adapt (and thus to change). With reference to this, the AWM is characterized by a more flexible strategy based on feedback and adjustment, providing it with enhanced capacities.

Althought, the adaptive (water) management approach has received recognition in the academic literature for its experimental logic as a tool to support decion making in complex natural resource management domain, a number of researchers have identified different obstacles that have prevented successful implementation and limited the realization of the benefits claimed to stem from AM (see Walters 1997; Habron, 2003; Levine, 2004). As adaptive water management (as well as the IWRM) requires reform(s) at the governace

(institutional) level as well as at the organizational process level, it is easy to belive that the implementation process of AWM will be long and hard. However, focusing just on how to change or remove those barriers still shaped by traditional "command and control" approach will not allow for a significant degree of change. Such process of major transformation that is surely needed is anyway slow. As consequence, focusing on how to initiate a process of change at the organizational level to adopt an adaptive water management, as shown by successuful examples in the Box, can be a valid option.

Box - Successful Example of Adaptive (Water) Management

Adaptive Water Management at a Local Scale in Borana (Ethiopia)

For this century climate projections for the Borana zone show a rise in temperature of circa 3 °C, and rain is expected to become more variable. During droughts small-scale agriculture will fail, livestock mortality will sharply increase and the productivity of livestock will decrease. Women and children left in the sedentary villages need to travel large distances to fetch drinking water. Within this context, the project ADAPTS[2] in Ethiopia focused on the potential of a small-scale water harvesting technique (sand dams) to help the local communities cope with the expected impacts of climate change. A strategy for building dialogues with the different levels of government was developed with the objective of including Community Based Water Harvesting (CBWH) into national and regional water policy level. One of the project's goals was to make policy makers aware of the potential impacts of climate change on Ethiopia. Furthermore, to promote sand dams in the future, training materials have been developed and are freely available. In the meantime, an Ethiopian knowledge centre on water harvesting has been created by the Oromia Water Bureau and the Ministry of Water Resources have given positive feedback about the potential of small-scale water harvesting to improve water supply in the country's semi-arid regions, and as a measure for adapting to the expected impacts of climate change. Despite the fact that this has not yet been explicitly translated into national policies, however the Borana Zone Water Resource Office has incorporated water harvesting in its five-year development plan for improving access to water.

[2] http://www.adapts.nl

Adaptive water management in the South Indian Lower Bhavani Project (Colombo, Sri Lanka)

The Lower Bhavani Project (LBP)[1] was the first major irrigation project initiated in India after independence in 1947 and was in full operation by 1956. The construction of the LBP reservoir has had a major impact on the socioeconomic development of the area, and that is still a productive irrigated area. The original design concept for the project was not accepted by farmers who opted for more water-intensive crops rather than the suggested 'dry crops'. In addition, a highly fluctuating climate and the transfer of water to urban areas have all been a challenge for agricultural producers. However, over time the interplay between farmers and water authorities has resulted in a flexible irrigation system that has adjusted to the natural seasonal variability in rainfall and annual water availability, the demands of society, at large, and the farmers. Besides this, the large-scale development of wells in the area shows how farmers have successfully managed to increase water availability to balance water scarcity during seasons without supply. The farmers have also acquired a capacity to swiftly adjust the cropping pattern to the highly unpredictable variability of seasonal canal water supply, and also to entirely rain-fed conditions. Within the LBP, social learning takes place both at the system and at the individual farmer's level. While, the uncertainty factors have been considered in a stepwise way during the system change cycles and have been included in the system design. As result of this, the system has moved from a top-down project to a management system with multiple actors. Hence, both farmers and the authorities have learned over the years and achieved a better capacity to interact. However, because the basin is closed with water resources already over- allocated to various uses. Yet, cities and industries, and users outside the basin, will demand more and agriculture itself is becoming less important to the economy.
To meet these future challenges, it is essential that policymakers recognize and build on the existing social capital and on negotiation and learning systems that have been developed insofar.

[1] http://www.iwmi.cgiar.it;

Box - Successful Example of Adaptive (Water) Management

Transition to ecosystem-based management of the Great Barrier Reef (Australia)

The Great Barrier Reefs[4] case study shows the critical role of flexible governance systems that can deal with complex and dynamic ecosystems by linking individuals, networks, organizations, and institutions across multiple levels of human activity. The Great Barrier Reef Marine Park in Australia covers 344,000 km2. The Reef itself generates essential ecosystem services and contributes € 4.5 billion annually to the Australian economy, 85% of which is from the tourism industry. In 1975 the Australian federal government enacted The Great Barrier Reef Marine Park Act in response to public interests over threats to the reef from oil drilling, mining, and unexplained outbreaks of coral-eating starfish. As scientific information accumulated it became clear that the Great Barrier Reef was becoming degraded, primarily from sediment runoff from land, overharvesting, and global warming. Within this context, a flexible organization, the Great Barrier Reef Marine Park Authority (GBRMPA), was crucial in initiating the transition to ecosystem-based management. In 1998 the Park Authority began a major rezoning of the marine park called the Representative Areas Program to systematically increase biodiversity by protecting representative examples of each type of habitat within a network of no-take areas. The GBRMPA was also active in the succeeding transformation of the governance regime and provided leadership throughout the process. Strategies involved internal reorganization and management innovation, leading to an ability to coordinate the scientific community, to increase public awareness of environmental issues and problems, to involve a broader set of stakeholders, and to manoeuvre the political system for support at critical times. The transformation process was due to the increased pressure on the Great Barrier Reef (from terrestrial runoff, overharvesting, and global warming) that generated a new sense of urgency to address these challenges. A common feature of GBR Marine Park Authority's strategy was anticipating and addressing potential barriers to the implementation of an ecosystem-based approach. According to this, the focus of governance shifted from protection of selected individual reefs to stewardship that can change patterns of interactions among key actors and allow for new forms of management and governance to respond to environmental change. Thus, this example illustrates that enabling legislations or other social bounds are essential, but not sufficient for shifting governance toward adaptive co-management of complex marine ecosystems.

[4] http://wetlandinfo.ehp.qld.gov.au/wetlands/resources/tools/gbr-pilot.html

Box - Successful Example of Adaptive (Water) Management

Governance, Institutions and Participation in the Orange-Senqu Basin (South Africa)

The case study of the Orange-Senqu Basin is one of six international river basins that serve as case studies for NeWater project[3]. The Orange-Senqu Basin is shared between four countries (Botswana, Namibia, Lesotho and South Africa). Since the 1990s there have been profound changes in the South African's legislation and policy, which have seen the incorporation of international trends and best-practice knowledge regarding water management. Water has become a common good, subject to national control, and perceived as a right to fulfil environmental and human needs. Thus, Integrated Water Resources Management (IWRM) is expressly included in government documents such as the National Water Resource Strategy and in the mean while, land-use management is perceived as a tool to accomplish IWRM. The central, top-down management system of water resources previously in place was given up in favour of a decentralised approach, in which provincial and local governments are levels in their own right and not functions of the national government. Furthermore, public participation is recognised as a cornerstone of the resource's management and local catchment management agencies (CMAs) and water users associations (WUAs) are established together with the elaboration of guidelines for public participation. Hence, South Africa can definitely be considered a leading state in terms of policy formation as well as institutional reform.

[3] http://www.newater.uni-osnabrueck.de;

4.2 WATER ORGANISATIONS: IT IS TIME TO CHANGE

Organisations together with governance have been identified both as forces that shape adaptive capacity and as system resilience (Eakin 2005; Folke, 2006; Reid and Vogel, 2006). A resilience perspective in governance and decision-making, according to Carl Folke, "*shifts policies from those that aspire to control change in systems…to managing the capacity of social-ecological systems to cope with, adapt to, and shape change*" (2006, 254). Part of creating a resilient system is increasing the system's capacity for continuous learning, adaptation, flexibility, and collective action. The challenge here is incorporating these elements into institutions and organizations for governance and resource

management (ibid.).

The implementation of a new water governance mechanism based on a non-hierchical, polycentric, and multi-level decision making requires the development of alternative forms of organisations able to deal with increased complexity, problems of coordination and communication posed by more horizontal decision-making processes and decentralisation. Research suggests that certain attributes and practices contribute to adaptive capacity and promote resilient systems, including flexible organisations, cross-scale interaction and knowledge sharing, and opportunities for collective and future-oriented learning (Adger et al. 2003; Agrawal 2008). Local organizations can either create an environment that enables actors to flexibly adjust to changing climatic stressors, or one that leaves actors with few options or opportunities to adapt (Eakin, 2005). These organisations may be particularly well-situated to mediate between stakeholders at different scales and to channel external information and resources for adaptation (Cash et al., 2006). Furthremore organizations can also promote collective learning that can lead to innovative ways of dealing with change (Armitage et al., 2008; Pelling et al., 2008). However, as stated in the paragraph 3.1 up to now it is not so clear how organisations build adaptive capacity in practical ways. As follows, in order to understand how adaptive capacity can be operationalized, a first question can be raised: what are the characteristics of adaptive capacity that make an organization able to choose the best fitting solution and implement it? In a "hypercompetitive" environment (D'Aveni, 1994), Staber and Sydow (2001) underline how organizations tend to act in two different ways. On the one hand, organizations following a reactive approach tend to adopt a "lean and mean" strategy, focusing in their core competencies, streamlining routines, and tightening resources belts (Harrison, 1994). On the other hand, organizations may adopt an alternative strategy by developing adaptive capacity. Following this line of though, another crucial question has to be answered: what are the inherent characteristics of an organization that make it able to develop adaptive capacity?

In the next sections, thus, I will focus first on adaptive capacity and on what adaptive capacity means both in institutions and organizations. Then, I will

critically analyses the capacities an organisation needs to acquire in order to: identify opportunities, gather resources, capture expertise, create partnerships and opportunities for dialogue, manage and monitor the entire process between decision making and implementation.

4.2.1 What is adaptive capacity?

The concept of adaptive capacity was firstly applied to ecological system (Holling, 1986) and analyzed within different theories (organization, resilience, governance and complexity). Then, it become the focus of climate change studies. More than ten years of studies have showed that the capacity of individuals, communities, organizations and governments to adapt to different sources of stress is a critical system characteristic. Within the SES research, such concept has been defined by the IPCC (2007; 2001) as: "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences". In general, the concept of adaptive capacity denotes the major human mechanism for managing system resilience, or the "ability to recover or adjust to change through learning and flexibility so as to maintain or improve into a desirable state (Engle and Lemos 2010, 4)." With reference to risk management and prevention, the evaluation of adaptive capacity plays a key role in supporting challenging decisions, such as where to allocate scarce resources (e.g. financial, social capital) to better face impacts of natural disasters or economical crises. While referring to policy perspective, the decision makers' interest is allocated in identifying and fostering specific system characteristics that (could) increase adaptive capacity.

Adaptive capacity is understood as a function of core assets from which adaptive action can emerge (Adger and Vincent, 2005a). Some of these determinants are interdependent, and may vary across time, space (Smit and Wandel, 2006) and scale (Posey, 2009). They embody economic wealth, collective action, human and social capital, perception of risk, equity, technology, information and skills, infrastructure and institutions (Pelling and High 2005; Adger, 2003; Yoke and

Tol, 2002; Smit and Pilifosova 2001, IPCC, 2001). However, among those determinants scholars underline the decisive role played by information and knowledge, participation and representation as well as social capital, networks and resource availability in shaping a system's adaptive capacity (Eakin and Lemos, 2006; Brooks et al., 2005; Adger, 2001). Since these components refer strongly to institutional and governance mechanisms, the currently prevailing idea is that the more flexible, democratic and participatory governance is, the more adaptive capacity increases, their potential for building and/or enhancing adaptive capacity has been extensively studied (Nelson et al., 2007).

After a decade of applied research, adaptive governance and the significance of learning mechanisms have been nowadays recognized as important tools for managing social-ecological systems during periods of rapid and unexpected change (Pahl-Wostl, 2007a; Folke et al., 2005). Furthermore, a number of authors have observed that adaptive governance systems often self-organize as social networks, with teams and actor groups that draw on various knowledge systems and experiences for the development of common understanding and policies (Folke et al. 2005). In the same line, the concept of adaptive co-management has been proposed for describing those flexible community-based systems of resource management tailored to specific places and situations and supported by, and working with, various organizations at different levels (Olsson et al., 2004, 77).

Mainly two different concepts - vulnerability and resilience - have been applied to assess adaptive capacity (Nelson et al., 2007, Brooks and Adger 2005, Cutter et al., 2003, Smit and Pilifosova, 2003). Even though adaptive capacity is characterized by being latent and thus difficult to measure in advance, new approaches to measure and characterize it combining insights gained in analyzing both the above mentioned concepts (Berman 2012; Engle et al., 2011). However, a lack of consensus about determinants of adaptive capacity (Adger, 2007) is among the causes of incomparability of different case studies. Difficulties can be identified in understanding whether or not the level of current or potential adaptive capacity resulting from policy assessment is optimal and if not why (Williamson et al., 2012).

4.2.2 Linking institutions, organisations, and adaptive capacity

Although institutions sometimes refer to organizations (see Newman, 2002) since these are formalised patterns of rules and decision-making, here they are considered as two different entities. Some researchers (Dooley, 1997, Crichton et al., 2009) have theorized organizations as complex systems characterized by interrelated agents that compose a network of connections that cooperate nonlinearly. However, organizations are here assumed as stand-in institutions embodying the nature and the processes of specific institutions.

Looking at the linkages between organizations and adaptive capacity, Burnard and Bhamra (2011) refer to organisation's inability to adapt to high-impact/low probability events as a result of systemic organizational weaknesses. Whereas, according to Staber and Sydow (2002), organizational adaptive capacity means the ability to cope with unknown future circumstances. Thus, organisations will try to experience actively the environment by applying existing and known routines (norms, ways of doing things, technologies, etc.) and to respond to a changing context reconfiguring themselves by innovating routines and articulating these in their practices.
Institutions instead refer to systems of established and prevalent social rules that structure social interactions (North, 1990; Hodgson, 2006), as well as to social structure composed of cultural-cognitive, normative, and regulative elements that, together with associated activities and resources, provide stability and meaning to social life (IDGEC, 1999, p. 14; Scott, 2001). Institutions are characterized by being inherently conservative (Gupta et al., 2008).

With reference to the new institutionalism approach, developed mostly in political sciences and sociology, the focus of analysis shifts from the architecture of institutions to the way in which individuals operating within the context of institutional frames affect adaptive capacity through their behaviour (Hall and Taylor, 1996; Nee, 2005). Gupta et al. (2010) looking at what are the relations between adaptive capacity and institutions, identify adaptive capacity in the inherent characteristics of institutions. Diaz et al. (2005) state that the adaptive

capacity of public institutions should be understood as the ability to pinpoint and solve problems in order to accomplish functions that facilitate the adaptive capacity of the different sectors of the civil society.

4.2.3 How was adaptive capacity of organisations assessed in earlier frameworks?

The enhancement of (water) institutions' adaptive capacity can be considered instrumental to manage uncertainty to climate change, but not only related to this, and therefore to foster flexible decision-making (Tompinks and Adger, 2005). As shown before, different frameworks have been developed to explore theoretical basis or to evaluate adaptive capacity. The first frameworks were focused on assessing the adaptive capacity of institutions and organizations to climate change considered as main driver of change. Whilst many researches are still focused only on organizational adaptive capacity to climate change, there are few studies considering the role-played by some other kind of drivers, such as legislative, customer behaviour, technology. Besides this, the Institutional Analysis and Development framework (IAD) developed by Elinor Ostrom (2005) provides significant insights even though not directly focused on adaptive capacity, but related more in general to institutional rational choice.

Climate change as core driver of adaptive capacity

The Performance Acceleration Climate Tool (PACT) arose from the EU-funded EPACE Project aimed to help organisations to assess and improve their response to climate change. The tool underlines strengths and weaknesses and potential next steps for enhancing organisations' response capacity to climate change. The tool collects evidence across nine complementary response "pathways", and assesses each one on a scale of achievement describing hence the excellence or mediocrity of an organization sector(s) and what steps to take next.

Arnell and Delaney (2006) assess the awareness and preparedness of water utilities in England and Wales to adapt to climate change.

The EU 6th Framework project "Adaptation and Mitigation Strategies: Supporting European Climate Policy (ADAM) examined institutional adaptive management and issues of adaptive capacity, in particular the role of institutions in supporting the implementation of measures (Lonsdale and McEvoy, 2009). Furthermore, the project also investigated how information about climate change is used and turned in to activities and programmes by organizations.

The frameworks proposed by Berkhout et al. (2006) and by Pelling and High (2005, 2008) provide a more theoretical approach even though built on direct experiences. The former designs a framework to analyse which factors facilitate adaptation to climate change in organizations working in the energy and water sectors taking into account what is known about how organizations learn and how and what may hinder the learning process within an organization. The latter aims to unpack the patterns of individual and collective action within an organization that can foster or constrain organizational adaptive capacity in the face of climate change.

Engle and Lemos (2010) analyse the characteristics of 18 Brazilian river basin councils in shaping the adaptive capacity of water systems to climate change.

Climate change as one driver of adaptive capacity

The method proposed by Yoke and Tol (2002) aims at assess the contributions of various adaptation alternatives to improving systems' coping capacity by focusing on the main determinants of adaptive capacity. On the basis of broad definitions, Yoke and Tol (2002) try to measure the adaptive capacity to a range of stresses and not only to climate change. Thus, they come up with the fact that many of the variables they assess cannot be calculated and many of the component functions can only be qualitatively defined.

The Adaptive Capacity Wheel is a method proposed by Gupta et al. (2010) to assess the inherent characteristics of institutions enabling adaptive capacity considers institutional strengths, weaknesses and opportunities for improvement. The Adaptive Capacity Wheel provide information on the ability

of institutions to stimulate the adaptive capacity of society to respond to climate change and on how and if institutions need to be redesigned to foster adaptive capacity. Another approach to institutional processes, developed in political sciences and sociology, is the New Institutional Analysis (NIA). It focuses on whether the institutional cultures of organizational settings constrain actors from dealing effectively with new circumstances, or whether such organizational cultures can actually facilitate adaptive capacity (Matthews and Sydneysmith, 2010). Thus, it provides a framework for assessing dynamic behavioural processes within organizational settings.

A more business-oriented approach has been suggested by KPMG[17] identifying ten traits that are common in organisations that are adaptive and that they states to be therefore more likely to survive. Thus, the more an organization will show the attributes listed (e.g. balance of leadership and management, effective internal communications, strong business model, etc.) in the proposed framework the more it will be adaptive and able to embed an adaptive culture which refers to bloom in an ever changing environment.

4.2.4 Analysis of organisational adaptive capacity characteristics

It is possible to assume that the extent to which an attribute can play a more or less crucial role to build adaptive capacity varies according to organizations' size and type. Notwithstanding, on the one hand, how and to which extent such characteristics might contribute to build the organizational adaptive capacity are not always clearly illustrated and furthermore some authors have expressly recommended that institutional structures be both a focus of further research, and a priority for building adaptive capacity (Berkes 2007; Leary et al. 2007; Reid and Vogel 2006; Cash et al. 2006; Eakin 2005). More research is needed to explore how the different attributes characterizing an organization are connected to each other, and if they are, which kind of relation (e.g. interdependency) is linking the different attributes. On the base of literature review of organizational behavioural, institutions, governance and climate change, (Engle and Lemos, 2010; Jones et al., 2010; Gupta et al., 2010; Diaz et

[17] KPMG is one of the largest professional services companies in the world.

al., 2005; Staber and Sydow, 2002) different indicators and criteria of organizational adaptive capacity can be identified as listed in Table 2. This table shows the attributes of an organisation identified with a diverse degree of detail by different scholars. The various indicators and criteria refer to organisational capacities allowing an organization: to pinpoint opportunities and take decisions, for instance using data and knowledge management (Yoke and Tol, 2002); to establish partnerships and networks to active learning processes and enhance its own capacities (Hulber and Diaz, 2013; Gupta et al. 2010; Engle et al., 2010; Agrawal, 2008); to collect and mobilise capacities (Hulber and Diaz, 2013; Gupta et al., 2010; Engle et al., 2010); to manage and monitor the mechanisms needed to undertake actions (Berkhout et al., 2006; Gupta et al., 2010); and to capture leadership qualities to lead the processes to change course or to acquire flexibility by reinforcing systems of interdependence and gaining legitimacy (Hulber and Diaz, 2013; Gupta et al., 2010). Moreover, as shown in Table 2, a number of characteristics even though named differently are common to different frameworks, such aì the capacity to tolerate mistake (Agrawal, 2008) and ability to bend (Engle, 2010), while other are proposed by individual scholars, e.g. clear mechanism for enforcing rules (Agrawal, 2008). However, a systemic framework to assess the adaptive capacity is lacking and most authors emphasize steps to be taken, rather than criteria to be met. Adaptive capacity is mostly seen as a “black box”, the process through which adaptive capacity is operationalized is not articulated and in general it is described as a result of pre-existing conditions (e.g. more or less of what are declared to be its determinants).

Reference	Indicators and criteria
Yohe and Tol, 2002	• The structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed • The ability of decision-makers to manage information, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers themselves
Berkhout et al., (2004; 2006)	• Degree of flexibility • Awareness of climate change • The existing resource situation • Relationship with water industry regulators • Trasparency
Agrawal, 2008	• Tolerate mistakes • Willingness to experiment • Promote social learning • Clear mechanism for enforcing rules
Gupta et al., 2010	• Encourage the involvement of a variety of perspectives, actors and solutions • Enable social actors to learn and improve their institutions • Allow and motivate social actors to adjust their behaviour; • Can mobilise leadership qualities • Can mobilise resources for implementing adaptation measures • Support principles of fair governance.
Engle et al., 2010	• Acconuntability and legitimacy • Degree of partcipation • Knowledge and information use • The power distribution among stakeholders, access to technical knowledge and the ability to express oneself freely • The ability of the institution to bend, but not break, and to learn through experience, speaks to its ability to manage crises effectively and efficiently • Commitment • Degree of network and connectivity • Ability to deal with everyday events and crisis situation • The level of financial and human capita
Hulbert and Diaz, 2013	• Vertical-horizontal institutional coordination and integration allow for the flow of information, resources and knowledge in multi-sectorial and multi-level governance processes, creating the conditions for learning and adaptiveness. • Reflexivity and social learning • Access to information (data collection and management) • Capacity in terms of leadership and resources • Equity

Table 2: Indicators and criteria of institutional and organizational adaptive capacity (source:Author)

CHAPTER 5: RESEARCH METHODS

In this chapter, I present the research questions, and provide an overview of the case-selection process, and a review of the methodologies that have been used throughout this dissertation.

5.1 RESEARCH QUESTIONS

From a social science perspective, it is relevant to understand the conditions under which institutions and organisations can favour adaptive capacity of societies to face potentially serious and irreversible impacts of drought risk. Furthermore, challenges posed by the projected impacts of environmental change on institutions and the awareness of the increasing unsustainability of the present water supply model have been investigated. The need of a shift in the water paradigm lead to focus on some critical questions:

- What characteristics of an institution define the capacity of water resources management systems to adapt to drought (and more in general to climate change)?

- Do organisations and their routines allow society to adapt fast enough to drought risk?

- And further, what are the barriers to the implementation of adaptive water management?

5.2 SELECTION OF CASE STUDIES

The case study areas here illustrated are not the result of a selection process, but they are more the consequence of collaborations with the Universidad Autonoma de Barcelona (UAB) and later with an Italian non-profit organization (ACRA). The former collaboration started with a PhD student working on the

attempt to incorporate resilience thinking and principles in urban systems governance and planning in Morocco, and in particular in the Draa Valley. Thanks to this collaboration I had the opportunity to analyze the failures of water institutions and the related adaptation strategies activated by rural communities in the North-African country and their impacts on water management.

The second collaboration started by participating to a meeting on corruption in the water sector organized by the Italian NGO ACRA-CCS. After that, I started collaborating with this NGO, and I got involved in a European Cooperation project in Bolivia "Integracion productiva de camélidos y quinoa en Tomave (Potosi)", which soon became my second PhD case study. Such project is localized in one of the areas that are most prone to drought risk in the Southern Bolivian Altiplano. The project was aimed to fight poverty in the communities improving the productive capacity of the main wage entries (lamas, vicus and quinoa) within a sustainable development framework (BOLTOM, 2009).

Despite their differences, some common characteristics may be found in the two case studies. Both the Draa Valley in Morocco and the Municipality of Tomave in Bolivia are experiencing the (positive and negative) effects of the globalization process because of tourism and global food market. The two areas are prone to a relevant drought risk and significative drought events within the local context have been registered in the past decade, afterwards described in the Chapter 4. Furthermore, both are localized in arid and semi-arid areas, which, as discussed in the section 2.1, are characterized by more frequent droughts comparing to other types of Earth lands. Both are under threat of desertification. Moreover, in 2011 and 2012 Morocco and Bolivia have been listed by the International Statistical Institute within the developing countries category on the base of their Gross National Income (GNI) per capita per year (ISI-web, 2013). Furthermore, despite of being governed by two totally different governmental and political systems both countries have adopted a new water management paradigm (integrated water resources management) and are promoting a change in their water management approach.

5.3 Case Study Analysis

5.3.1 Data Collection

The first data source for this dissertation was literature, archival data published and unpublished research and reports on historical, socio-economic and political, cooperation projects as well as area-specific issues, such as drought plans, projects on water infrastructure and legislations that were available online. They have been reviewed and used as background information, and to strengthen presentation of findings and analysis.

The second data source is composed by information collected through:

- Fieldworks in the case study areas of Tomave (Bolivia) and Draa Valley (Morocco), which have been conducted to understand how the new water management paradigm is being implemented and how institutions adapt to drought risk within this new reference context.
- Open questions interviews with communities' members
- Open questions interviews with the persons in charge of governmental and non-governmental organizations participating in different phases of disaster risk management.
- Open questions interviews with the person in charge of Quinoa production organization in Bolivia.
- Semi-structured interviews with decision-makers from governmental and non-governmental organizations participating in different phases of disaster risk management.
- Snowball sampling (Biernacki and Waldorf, 1981; Atkinson, and Flint, 2001) in Morocco
- Semi-structured interviews with water managers and decision-makers working in water institutions and university researchers supporting them.

5.4.2 Search Strategy for a Literature Review

To determine the relations among the different factors composing the present PhD research and to understand how broadly science addresses the topic of institutional adaptive capacity and water management to face drought risk a literature review was conducted through Web of Science, Scopus, Taylor and Francis as well as key journals such as Ecology and Society, Water Resources Management, Natural Hazards, Disasters. The string of search terms had two components that were combined with the Boolean operator AND. Different combinations were explored, as showed in Table 3.

Furthermore, as the countries selected as case studies are not English mother language, the terms were sought referring to their corresponding terms in Spanish and France languages. The terms included in the search were adapted according to the thesaurus of the respective database (see Annex 1).

AND	Drought	Drylands	Water	Drought Management	Adaptive Capacity	Adaptive Management	Water Governance	Water Institutions	Institutional Adaptive Capacity
Drought	✗	✓	✗	✓	✓	✓	✓	✓	✓
Drylands	✓	✗	✗	✓	✓	✗	✗	✓	✗
Water	✗	✗	✗	✗	✗	✓	✗	✗	✗
Drought Management	✓	✓	✗	✗	✓	✓	✗	✓	✓
Adaptive Capacity	✓	✓	✗	✓	✗	✓	✓	✓	✓
Adaptive Management	✓	✗	✓	✓	✓	✗	✓	✓	✓
Water Governance	✓	✗	✗	✓	✓	✓	✗	✓	✓
Water Institutions	✓	✓	✗	✓	✓	✓	✓	✗	✓
Institutional Adaptive Capacity	✓	✓	✗	✓	✓	✓	✓	✓	✗

Table 3: Combinations of research terms and the Boolean operator AND

5.3.3 Notes and data recording.

In my work field, I used two different recording techniques to collect the data:

Note taking: Note taking was the most frequently used method to record data. My notes included the names of the informants, the role within institutions, organization or a community and the dates and places of interviews. Notes were taken during both formal and informal interviews and elaborated later. A careful crosschecking of interpretations of what respondents to said, or how they understood their own or other people's words, was ensured. All the interviews I conducted or participated today, I added to my own observations and comments.

Audio recording: This study used extensively audio recording as a method and in order not affect the progress of my research and to avoid negative reactions, all the interviewed where informed in advance of the use of a laptop and I requested permission to use it to record the interview. This device gave me an opportunity to record for all the needed time, and to catch up with what I had missed during the interview session.

5.4 Fieldwork and Interviews in Bolivia

In Bolivia, the interview process was facilitated by the support of the Italian NGO ACRA I was working with. Such partnership gave me the opportunity to be in contact with top governmental managers, within the emergency management sector, with various indigenous community leaders, with other international NGOs working in Bolivia. Another relevant source of information came from the "Centro por el agua" of the Universidad de San Simon de Cochabamba, which is the governmental scientific reference about water management. However, the limitations of the archival records on the history of local adaptation to drought made it necessary to talk to the communities themselves and learn from them. Therefore, much of the study time prior to the surveys was spent by visiting selected sites for the purpose of observation and informal interviews. This was necessary to make myself known by the people living in the Southern Altiplano,

conceptualize the problem on the ground, and consequently to plan for formal interviews. This period of familiarization and observation helped me to gain extensive background information on drought and water management problems and helped sharpen the focus of my study. The method applied during the first round of interviews had its limitations.

Firstly, the respondents were not systematically selected. We just happened to live together and talk.

Secondly, the issues discussed were never entirely controlled. A topic would come up and be discussed spontaneously and was discussed there and then. Therefore, data generated this way left many gaps regarding the response to drought topic.

Thirdly, the data generated through observation and informal interviews was not enough to bring out completely the Southern Altiplano people's cultural interpretation of drought, and how they cope with drought. Therefore, there was a need for a more systematic data collection technique specifically designed to explore how drought risk is faced and how water institutions adapt to drought. Thus, I planned three-steps interviews. I first interviewed using open questions the persons in charge of different organizations: four of them working in the field of emergency (Table 4), and the general manager of production and marketing of quinoa in the Municipality of Tomave (Table 5). The open questions submitted to the institutions operating in the emergency field were aimed to understand: which kinds of droughts they are facing off (1); how and when a disaster and a state of emergency is declared, in particular with reference to droughts (2); how an emergency is managed once it is declared (3); gaps between laws system and operational activities (4); cooperation activities between Bolivian government and international organizations working in the emergency sector.

The interview with the responsible for quinoa marketing (ARPAIAMT) was focused more on understanding: (1) ARPAIAMT mission and activities; (2) quinoa market price fluctuations and quinoa production; (3) past droughts and measures taken to reduce their socio-economic impacts; (4) activities promoted

by ARPAIAMT to produce quinoa in a more sustainable way and to cope with future droughts and other risks present in the area.

Bolivia			
No. Respondents from the institutions	Sector	Institution	Specific Competences
1	Government	Viceministerio de Defensa Civil	The Vice Ministry of Civil Defense (established by S.D. 29894 on February 7, 2009) plans and executes actions of risk reduction, disaster and / or emergency coordination with departmental, municipal, private, national and international organizations, promoting the participation of the Armed Forces in the National Civil Defense System.
1		Unidad de Gestion de Riesgo - Gobierno Autonomo Departamental de Potosi	The Risk Management unit belongs to the Secretary Department of Agricultural Development and Food Security, which has the primary mission of supporting the Department potentially productive sectors, boosting its coor-dination and integration in complex agricultural, food security, productive infrastructure, the rural and urban micro enterprises to contribute to family economic growth.
1	Third parties (NGOs, International Agency, Knowledge Institues)	Cooperazione Internazionale (COOPI)	COOPI BOLIVIA has carried out diverse operations within the segments of water, food security, humanitarian assistance and governance. The water sector, in particular, is one in which concentrates the majority of the interventions.
1		Unidad de Coordinacion de Emergencias y Rehabilitacion (FAO Bolivia)	FAO Representation in Bolivia recently implemented Coordination Unit FAO Emergency and Rehabilitation (UCER) In order to provide timely and multidisciplinary responses to various emergencies caused by natural causes, usually caused by climate change, such as floods, droughts, earthquakes and others that can be produced by the same man.

Table 4 : Interviews with institutions in charge of emergency management in Bolivia

Bolivia			
No. Respondents from the institutions	Sector	Institution	Specific Competences
1	Agriculture	Asociacion Regional de Productores Agropecuarios Integral Ayllus del Municipio de Tomave "ARPAIAMT"	ARPAIAMT is part of the association “ANAPQUI”. It is a regional organization at level of ayllu enganged in the production and marketing of quinoa.

Table 5: Interviews with institutions in charge of production and marketing of quinoa.

Besides this, I had the opportunity to work actively aside of the project evaluator during the evaluation phase of the project. Within this phase, we met with 14 communities. During these meetings according to the age of people present in the meeting, we divided the community in three groups and to each of them we asked to draw their territory. The older people were asked to draw their territory showing how it was ten years ago, adults were asked to draw the present situation, and the younger people were asked to show how they imagine their lands in the future - five-ten years. Once finished to draw, the different groups had to explain what they drew to all the others. In some communities drawing the map created a temporary window of opportunity to narrow the gap imposed by the hierchical structure of the indigenous communities and to discuss the current development strategy and question it with a keen interest of all the communities stimulated by the wishes of the younger people.

At the end of this activity and after having helped in moderating the discussion, I had the possibility to conduct the questionnaire with the person in charge of water management in Opoco, Totora K, Chiutaca, Tomave, Ventilla, and El Asiento (Figure 6). This final step of the interview process will be described in the next section.

To sum up, during my fieldwork I followed these four basic issues listed below:

- Identify the related organizations that are involved in the subject: risk and water management;
- Collect reports and archival data of the related organization;
- Conduct interviews with the sample key personnel of the organizations working on risk management;
- Conduct questionnaires with the sample key personnel of the organizations working on water management.

Figure 6 : Geolocation of the conducted interviews with water management managers (source: Author)

5.5 FIELDWORK AND INTERVIEWS IN MOROCCO

In the case of the Moroccan case studies, some contacts were provided to me within the collaboration, earlier described, with the Autonoma Universidad de Barcelona, in particular with the "Groupe de Recherche sur l'Impact, la Vulnerabilité et l'Adaptation au Changement Climatique au Maroc (GRIVAC)" of the Université Cadi Ayyad in Marrakesh and the Observatoire National de la Secheresse. Moreover, before moving to Morocco for the fieldwork, I spent some time surfing on Internet to identify researchers working or that have worked in the Draa Valley. Although it was a time consuming activity thanks to it I established contacts. Among those I was in contact with the coordinator of the IMPETUS Project[18], who provided me information about who are the persons in charge of water management in the Draa Valley. Furthermore, because of high level of burocracy requiring a considerable volume of documents to be presented in order to have a talk with the persons in charge and to be able to get some relevant data once finished the interview, I decided to try to reach those people through informal contacts (e.g morroccan and aid-workers friends).

I was aware that the success of my idea to apply a snowball sampling would depend greatly on the initial contacts and connections made, but I was quite confident with that due to the work done earlier. Thus I went to through the decision taken and it allowed me to access to an informal network of contacts. Hence I had the opportunity to come in contact with some water officers, who were not easy to be in touch with. Once identified the responsible of the different institutions, in-depth interviews were conducted.

To sum up, during my fieldwork I followed these four basic issues listed below:

- Identify the related organizations that are involved in the subject: risk and water management;

[18] The IMPETUS Project (2000-2009) applies a multidisciplinaty perspective in order to solve present and possible future problems with regard to fresh water supply. It was supported by the Federal German Ministry of Education and Research (BMBF). http://www.glowa.org/eng/impetus_eng/impetus_eng.php

- Collect reports and archival data of the related organization;
- Conduct interviews with the sample key personnel of the organizations working on risk management;
- Conduct questionnaires with the sample key personnel of the organizations working on water management.

Morocco			
No. Respondents from the institutions	Sector	Institution	Specific Competences
1	Third parties (NGOs, International Agency, Knowledge Institutes)	Observatoire National de la Secheresse	The National Drought Observatory (ONS) was created in 2001 as an entity attached to the General Secretary of MARD and based at the Institut Agronomique et Vétérinaire Hassan II (IAV), as a result of a ministerial decision to locate it physically in an academic institution allowing multidisciplinary collaboration, and giving it certain neutrality with regard to policy pressures. The main mission of the Observatory is to provide decision makers with decision support tools for drought management and to advise on strategic drought planning, preparedness, mitigation and response.

Table 6: Interviews with institutions in charge of emergency management in Morocco

5.6 Interviews with organisations in charge of water resources management in Bolivia and Morocco

The study of adaptive capacity of organisations was carried out by means of a questionnaires submitted to a number of representatives from organisations in charge of water resources management in the Draa Valley (Morocco) and the

Municipality of Tomave (Bolivia). The questions that composed the questionnaires are listed in the Annex 2; each of them, in addition to requesting information on how effective is the institution in addressing future and unexpected problems, also asked to respondents to assign a grade from 1 to 5 (for 'how effective' questions, 1 = not effective, 5 = very effective; for 'to what extent' questions, 1 = never, 5 = routinely) reflecting the capacity of the institution to identify, defining, and scoping a problem as well as evaluate solutions to a problem and implement solutions. However, these scores were not used to obtain a final score given the characteristics of adaptive capacity concept earlier described, but they have been used to understand how the routines internal to these organisations favour or impede adaptive capacity in order to face drought risk, climate change, and the uncertainties related to them.

5.7 Re-framing adaptive capacity of organizations and its determinants

During my PhD internship at Cranfield University I had the opportunity to work for the European project "Transitions to the Urban Water Services of Tomorrow (TRUST)" aiming at delivering co-produced knowledge to support Transitions to the Urban Water Services of Tomorrow, enabling communities to achieve a sustainable, low-carbon water future without compromising service quality (www.trust-i.net). Within this project, I developed a conceptual framework to assess the adaptive capacity of organisations and understand how adaptive capacity can be operationalized. Therafter, the developed framework has been tested in the two case studies, in Bolivia and in Morocco.

On the basis of the characterisitcs identified by the literature review carried out and described in the paragraph 4.2.4, it can be stated that within an organization not all attributes are equally strategic (playing the same role) and they are not all used contemporaneously by an organization to accomplish a goal. According to this, I clustered the different characteristics present in the reviewed literature on the base of two categories that I identified, the "Process"

and the “Capacities”, which respectively refer to the problem management phasis and to the capacities to run organisational routines.

1. The “Process”

The term “process” is used to refer to operational concept that enable an analyst to point out the structure applied by an organization to deal with issues, seek for solutions, implement solutions and monitor the effectiveness of applied actions. Problems can present different characteristics; they could be at decision, management and/or at operational level. A set of four dimensions is used to describe the process, which works as a cycle and includes (1) problem finding, (2) problem shaping, (3) problem solving, and (4) decision taking (Figure 7).

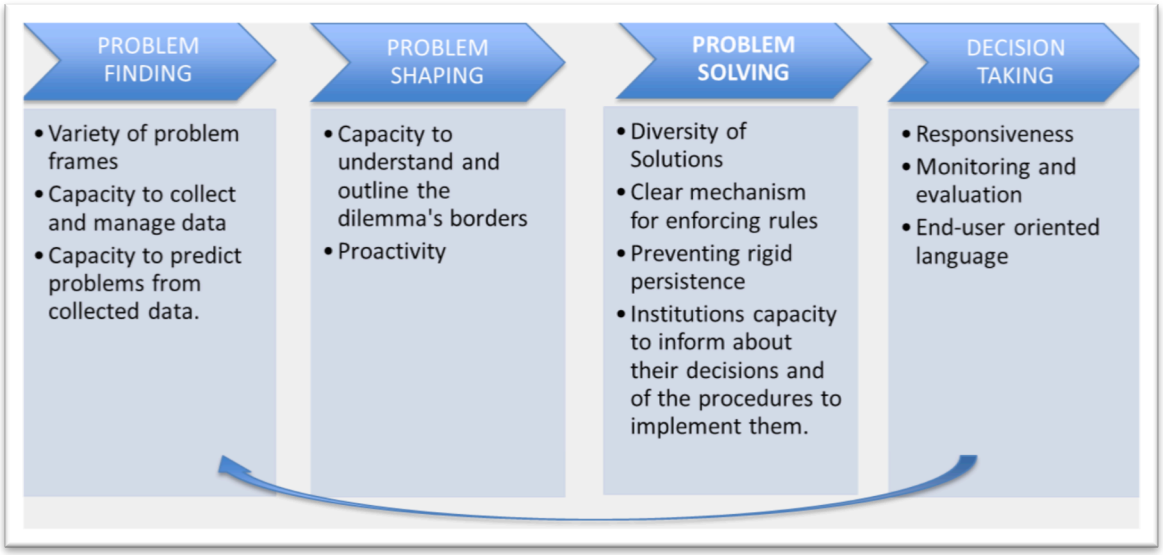

Figure 7: the “Process” and the working mechanism (source : Author)

The first dimension, “problem finding”, refers on one hand to the capacity of an organization to use a variety of problem frames. Within an organization, “variety” could refer to dynamic capabilities (Collins, 1994) as processes of search of alternative ways to responding to different situations, changing and adapting its routines (Cyert and March, 1963). Gupta el al. (2010) highlight how “variety” implies that there is no single applicable frameworks as well as there is no single best policy or strategy, but that there are many. Staber and Sydow (2002) refer to variety in terms of “multiplexity” underlining how sharing information within a system may bring in diverse knowledge enhancing thus the

organizational system's flexibility in responding to demands arising from the environment. In the same vein, Engle and Lemos (2010) state that interactions and negotiations at all levels between institutions and stakeholders by increasing the variety of perspectives does not only enhance their adaptive capacity but permit even to consider diverse interests like those of non-human and of future-generations. Further, Diaz and Hubert (2013) recognized the need to change the traditional approach of public sector to environmental problem in order to address climate change challenges and suggest integrating non-public actors in the process, avoiding thus strategies, conditions and norms dictated by the state. In agreement with this, "variety" is here understood as the capacity to view the situation through a different layer, reformulating problems from other angles, as well as the ability to change the paradigm of reference. On the other hand, the "problem finding" clusters together the capacity to collect data to provide information regarding a specific topic and the capacity to predict problems based on the collected data, being sensitive to perceive a situation in which there are problems or to recognize a situation as problematic (even using weak signals).

The "problem shaping" phase aims to assess the organizational capacity to process data following two criteria: (a) the capacity to understand and outline the border of the dilemma to solve, because recognizing the existence of a problem is not enough to change the situation. Thus it is necessary to define and describe the dilemma and provide information in a manner that allows managers to shape policy without limiting their ability in designing solutions to the dilemma; (b) the way in which procedures (reactive and/or proactive mode) are initiated to work it out. The capacity of an organization to open proactively communications with all stakeholders in order to build consensus between all interested parties and establish a shared vision that serves everyone.

The third dimension refers to "problem solving". Problem solving should not refer only to the capacity of developing appropriate, innovative solutions, but also to the ability to make decisions under uncertainty and choose reversible options. In other words, the idea is to favour strategies that are reversible and flexible over irreversible decisions (Smith, 1997, Hallagate, 2009). With reference to this, in this phase it is crucial to develop shared solutions to avoid

barriers, to disseminate and communicate the decisions taken, and to choose through a participatory process the enforcing rules as simple as possible, but as complex as necessary.

The last step of the process is the "decision taking". It aims to assess: (1) the capacity of the public institutions to evaluate their degree of implementation, correspondence to the criteria defined and to monitor the application of the solutions and the success of the applied solutions; (2) the responsiveness in terms of capacity to be receptive to feedbacks and to respond to. Thus, organizational adaptive capacity is assessed according to the four different dimensions, and within each dimension it is further assessed according to the different criteria.

2. The "Capacities"

The category of "Capacities" identifies those attributes acting as framework, which supports and allows organizations to operate and face different issues during the day-to-day activities as well as during the emergence phases. According to the stages of the process earlier described, an organization use specific inherent characteristics to carry out an activity. Thus, as shown in the Table 7, the different attributes described in the reviewed literature and listed in the right coloumn of the table have been framed according to the five clearly identified dimensions (left coloumn of the table): (1) learning capacity (of institutional structures); (2) individual learning capacity; (3) sharing and negotiating; (4) leadership; (5) capacity. These five dimensions have been selected for two main reasons. On one hand, because the co-existence of these five pillars creates the conditions to develop a cycling learning and evaluative process allowing an organization to adopt different configurations and adapt its decision-making procedures to changing circumstances. On the other hand, because of their capacity to embed direct and indirect correlations between the different inherent characteristics, such as self-organization (individual learning capacity) and leadership, generating tensions within a same organization. In the following paragraphs, the different dimensions and criteria are analysed in

order to understand their role in enabling or not the adaptive capacity of an institutional structure.

DIMENSIONS	ATTRIBUTES
LEARNING CAPACITY (organizational)	Ability to deal with everyday situation
	Ability to deal with crisis situation
	Willingness to experiment
	Institutional memory
	Single-, double-, and triple loop
	Trust
LEARNING CAPACITY (individual)	Willingness to change and to adapt
	Preparedness to experiment
	Continuous access to information
SHARING AND NEGOTIATING	Availability of data to external subjects
	Multi-actor; multi-sector; multi-level (vertical and horizontal)
	Connectivity
	Degree of Network
	Ability of different agencies to communicate and constructively to debate ideas, information, and solution to problems among themselves.
LEADERSHIP	
RESOURCES	Human Resources
	Financial Resources
	Technological Resources

Table 7: Dimensions and attributes of the inherent characteristics (source: Author)

Organisational Learning Capacity

The relevance of learning to enhance adaptive capacity is widely recognized in literature that provides a rather nuanced view. Institutional memory refers to the ability to learn through the evaluation of processes of policy experiences (e.g. performance reporting) and convert weaknesses into opportunity by

promoting social learning. Moreover, learning is related to experience as ability to deal with everyday events, as well as extremes, in an effective and efficient way (Engle and Lemos, 2010). As follows, learning refers also to how experience enables questioning (and if needed modify) ideologies, frames, routines, roles and rule as well as how problems are set and solved (Gupta et al., 2010; Staber and Sydow, 2002). The incapacity of an institution to realize the need to develop new knowledge (Cohen and Levithal, 1990) may turn organizational capabilities into rigidities (Leonard-Barton, 1992) under conditions of dynamicity and uncertainties. Instead, organizational reflexivity allows an organization to transform the context the organisation operates within (Brockhaus et al., 2012; Staber and Sydow, 2002), without experiencing the environment passively. Goodin (1996) suggests that institutional learning includes willingness and preparedness to experiment. With reference to this, different types of learning demanding incremental focus on the sub-text of learning can be identified in literature. Single-loop learning suggests an incremental enhancement of action strategies without questioning the underlying assumptions. Double-loop learning (see Argyris and Schön, 1978) refers to a re-examination of assumptions (e.g. about cause–effect relationships) within a value-normative frame- work. In triple-loop learning (see Hargrove, 2002) one starts to review core values and beliefs, worldviews, if assumptions within a world view do not hold anymore. Besides this, Gupta et al. (2010) underline how learning by requiring trust among the different social actors can enhance adaptive capacity.

Individual Learning Capacity

Individuals understand and evaluate desirable states of development and of risk ground of different knowledge, interests and values: this must be taken into account when considering adaptive capacity (Otto-Banaszak et al. 2011). Pelling and High (2005) underline the need to open informal spaces within organizations where individuals and sub-groups can spontaneously share, learn, and reflect on how they act or experiment (Agrawal et al., 2008). On the contrary, institutions, which do not provide sufficient autonomy to individuals or groups to adapt their behaviour in response to changes, are likely to constrain or reduce their adaptive capacity (Williamson et al, 2012; Inderberg,

2011; Gupta et al 2010). In turn, within the UNDP's Adaptation Policy Framework for Climate Change, the willingness to adapt is listed as a key component of adaptive capacity. The latter depens heavily on leadership and on responsibility acceptance by key stakeholders (Lim et al., 2005). Brockhaus et al. (2012) in describing the results of the interviews in the 4 municipalities/districts in Burkina Faso list different qualities, such as motivation, curiosity, open-mindedness, etc., as qualities to be a "good adapter".

Sharing and Negotiating

In their process of unpacking governance, Engle and Lemos (2010) identify the capacity to network, to connect as attributes of institutional adaptive capacity. Furthermore, they connect such characteristic together with the use of knowledge as features to both support social learning and flexibility of institutions. Institutional coordination, according to Diaz et al. (2005), involves the ability of different agencies to communicate and constructively debate ideas, information, and solution to problems. Tompkins and Adger (2004) state that adaptive capacity is enhanced by the existence of institutions and strong networks which learn and gather both knowledge and experience as well as plan for changing environmental and policy settings and risks. In turn, Folke et al. (2005) emphases the need to foster adaptive, flexible, and learning institutions at different scales, in order to respond to the non-linear dynamics of natural resources and human systems. The importance of coordination of a multi-actor, multi-level and multi-sector approach to enhance adaptive capacity within an institutional structure is recognized by Gupta et al. (2010), Brockhaus et al. (2012), and the National Adaptive Capacity Framework (World Resources Institute, 2009). Woolcock (1999) states that not all the networks are positive; Putnam (1993) warns that norms and networks may act as means of discrimination or social segregation as well as may reinforce the power of some elites (see Marcus, 1983). Non-members may be margibalized (Brockhaus et al., 2012), sources of information and contacts can be monopolized (Das Gupta, 2001).

Leadership

Danter et al. (2000) underline that in a learning environment continuous testing and change of leadership within management organizations is required. With reference to this, Gupta et al. (2010) underscore the role of leadership in promoting a change or in motivating others to follow. According to the "Ten traits of Adaptive Organizations" developed by KPMG, leadership can be identified throughout the whole organisation. It is exhibited by all who encourage others to accept, support and even embrace new behaviours. Darini et al. (2011) in their assessment of adaptive capacity of small and medium enterprises referring to leadership, management and governance structures look at balancing the necessities of internal and external stakeholders finalized to ensure a good governance and decision-making process even during emergencies. Consistent with Darini et al. (2011), Yoke and Tol (2002) refer to leadership as the capacity to determine what information is reliable, the processes by which decision-makers define which information is trustworthy, and the credibility of the decision-makers themselves. Judge and Douglas (2009) in their literature review of the organizational change capacity (OCC) highlight the relevance of the leadership and in particular of a trustworthy leadership (see Barney and Hansen, 1994) as a dimension of organizational change capacity.

Resources

Many authors (Gupta et al., 2010; Engle and Lemos, 2010; Diaz et al., 2005) refer to such dimension in terms of financial and human labour attributes; others list as relevant even other resources as social capital (Brooks and Adger, 2005); authority (Gupta et al., 2010); education and wealth (Engle and Lemos, 2010).

5.9 Operationalization of Organisational Adaptive Capacity

The mechanism of operationalization of adaptive capacity is described by Table 8, which shows the relationship between the two categories, the Process" and

the “Capacity” both described in the paragraph 5.8.

Table 5 is a double entry level table composed by two axes: “What” and “When”. “What”, in the column”, is related to the category “Capacities”. This is composed by five dimensions and by a set of capacities composing each dimension. The “Organisational Learning Capacity” dimension refers to: (1) ability to deal with everyday and crisis situation which underlines the capacity of an organisation to deal with uncertainties and surpriceses, to think on the base of possible scenarios, and the availability of an emergency plan to follow as references. (2) willingness to experiment refers to the ability to take the risk of making mistakes; (3) institutional memory concers the ability of an organisation to learn through the evaluation of policy experiences and enhance the abilities converting weaknesses into opportunity. (4) Single, double, triple loops refers to the capacity to learn and thus to reform routines by enhancing them or by changing its core values; (5) “Trust is the capacity to develop ties based on trust both between individuals and groups within an organisation, and between an organisation and its stakeholders.

The “Individual Learning Capacity” is made up by (1) willingness to change and to adapt refers to che capacity to embrace change and take personal action to prevent problems; (2) preparedness to experiment is related to the capacity to increase the individual capacity to self-organize and innovate fostering social capital; and (3) continuous access to information. The latter, “continuous access to information” concerns the existence of a solid and updated accumulation of information. Information should be easily accessable and easily sharable among individuals, teams and units within an organization.

Sharing and Negotiating is composed by: (1) availability of the data to external subjects; (2) connectivity; (3) degree of network (4) multi-actor, multi-sector, and multi-level (vertical and horizontal); and (5) ability of an institution to communicate and constructively to debate ideas, information, and solution to problems among different agencies.

“Availabiliy of data to external subjects” refers the capacity to share data with public organisations, organizations of the civil society, and individuals.

“Degree of network” indicates the number of connections that an organization has.
“Multi-actor, multi-sector, and multi-level (vertical and horizontal)” refers to the capacity to involve various actors, administrative levels and sectors in the problem management process.
“Connectivity” which refers to the capacity to establish linkages in multi-sectorial and multi-level governance processes that allows the flow of information, resources and knowledge creating the conditions for learning and adaptiveness.
“Ability of an institution to communicate and constructively to debate ideas, information, and solution to problems among different agencies” concerns the ability of an organization to reflex about and to learn from other systems (formal and informal) avoiding the problems of organisational silos (uncommunicative, non-interactive organizations and practices) as well as to deal with a multiplicity of challenges, and change trajectories and practices as required.

Leadership sums up the insights described earlier in this section as the capacity to manage the different processes.

Resources refer to the availability of human, financial and technical resources both to reach a goal and to reform organizational routines.

“When”, in the row, refers to the category of the “Process” composed by four phases and by a range of attributes. The problem-finding phase is made up by the three attributes: (1) variety of problem frames; (2) capacity to collect and manage data; (3) and capacity to predict problems from collected data.

“Variety of problem frames” referes to the capacity to view a dilemma that need to be solved through different frames, to reformulate the problem from other standpoints and/or change the paradigm of reference.
“Capacity to collect and manage data” concerns on the one hand with the capacity to agree in goals, definitions, and methods to collect data, and on the other hand with the capacity to organize data in a way that contributes to a better knowledge of the existing resources and facilitating their management in ordinary situations as well as in situation of uncertainty and surprise.

“Capacity to predict problems from collected data” is related to the capacity to be sensitive to perceive a situation in which there are problems, to recognize a situation as problematic.

The problem-shaping phase is composed by two attributes: (1) Capacity to understand and outline the dilemma's bordes, which emphases the capacity to define the features of a situation that need to be resolved; (2) proactivity indicating the action of acting in advance to deal with an expected difficulty.
The problem-solving phase comprises four attributes: (1) diversity of solutions, such as the capacity to develop appropriate, reversible, and innovative solutions as well as the ability to make decision under uncertainty; (2) clear mechanism for enforcing rules; (3) preventing rigid persistence, which refers to conflict management for creating constructive solutions; (4) and organisational capacity to inform about their decisions and of the procedures to implement them.
The decision-taking phase is made up by three attributes: (1) responsiveness; (2) monitoring and evaluation; (3) and end-user oriented language. “Responsiveness” refers to the capacity of an organization to acquire feedbacks and respond to such stimuli. Whereas, “monitoring and evaluation” means the capacity of an organisation to monitor the application of the solutions undertaken and to evaluate their degree of implementation, correspondence to the criteria defined and success of such solutions.

Each flag in the table highlights the existence of relation between a specific capacity (“What”) and the phase of the process (“When”) in which this specific organizational capacity is used. Furthermore, each flag regarding the same capacities shows how such ability plays a different role according to the specific problem management pahse it refers to. For instance, in the problem-shaping phase institutional memory may refer to a learning process related to mechanism of defining and scoping a problem, whereas within the problem-solving phase the same attribute, institutional memory, indicates the capacity of an organization to design potential solutions to a problem on the base of the acquired experience.

What/when			The Process												
			PROBLEM FINDING			PROBLEM SHAPING		PROBLEM SOLVING				DECISION TAKING			
			Variety of problem frames	Capacity to collect and manage data	Capacity to predict problems from collected data.	Capacity to understand and outline the dilemma's borders	Proactivity	Diversity of Solutions	Clear mechanism for enforcing rules	Preventing rigid persistence	Organisational capacity to inform about their decisions and of the procedures to implement them.	Responsiveness	Monitoring and evaluation	End-user oriented language
The Capacities	**LEARNING CAPACITY (organisational)**	Ability to deal with everyday and crisis situation	✓	✓	✓	✓	✓	✓	✓	✓	✓			
		Willingness to experiment	✓	✓	✓		✓	✓			✓			
		Institutional memory	✓		✓	✓		✓					✓	
		Single loop	✓	✓				✓			✓		✓	
		Double loop	✓		✓	✓		✓	✓		✓		✓	
		Triple loop	✓		✓	✓		✓	✓	✓	✓		✓	
		Trust		✓	✓						✓		✓	✓
	LEARNING CAPACITY (individual)	Willingness to change and to adapt	✓	✓			✓	✓		✓		✓	✓	
		Preparedness to experiment	✓		✓	✓	✓	✓		✓		✓	✓	
		Continuous access to information	✓	✓	✓	✓		✓					✓	✓
	SHARING AND NEGOTIATING	Availability of the data to external subjects									✓	✓	✓	✓
		Connectivity			✓	✓	✓	✓			✓	✓		✓
		Degree of network	✓	✓	✓		✓		✓	✓	✓	✓	✓	
		Multi-actor; multi-sector; multi-level (Vertical and Horizontal)	✓		✓	✓		✓			✓	✓	✓	✓
		Ability of an institution to communicate and debate ideas and solution to problems among different agencies	✓		✓	✓		✓			✓	✓		

What/when			The Process											
			PROBLEM FINDING			PROBLEM SHAPING		PROBLEM SOLVING				DECISION TAKING		
			Variety of problem frames	Capacity to collect and manage data	Capacity to predict problems from collected data.	Capacity to understand and outline the dilemma's borders	Proactivity	Diversity of Solutions	Clear mechanism for enforcing rules	Preventing rigid persistence	Organisational capacity to inform about their decisions and of the procedures to implement them.	Responsiveness	Monitoring and evaluation	End-user oriented language
The Capacities	LEADERSHIP		✓		✓	✓	✓	✓		✓			✓	
	CAPACITY	Human Resources	✓	✓	✓	✓	✓	✓				✓	✓	
		Financial Resources	✓	✓			✓	✓				✓	✓	
		Technological Resources		✓				✓				✓	✓	✓

Table 8: What/when. Correspondences between capacities and process attributes

5.10 Adaptive Capacity and time scale

Furthermore, the conceptual framework here proposed can be used to assess the capacity of organisations to respond to different types of problems, here identifies as: unexpected, current, and future dilemmas (Figure 6). Within the category of "unexpected problems" are clustered together all those problems characterized by being unexpected and requiring the activation or use of those routines applied during the "emergency time". This can be the case of unrecognized state of drought due to a lack of a monitoring system, of earthquakes affecting the pipeline system, of a black-out cutting off the energy power of water pumps used to capture underground water or to control water

flows for cropping. Once the emergency phase is over, unexpected problems may become current problems, in terms of capacity to acknowledge them, for which routines are established and updated. Current problems refer to all those issues happening during the "peace time" and being characterized by a short-medium-term solution, such as water quality, customer expectations, and regulations. However, as stressed by Evans et al. (2004) referring to flood risk, 'decisions taken today will have a profound impact on the size of flood risks that future generations will need to manage. They will also strongly influence the options available for managing those risks' and while transferring such concept to manage problems it is possible to note how current problems may hide and thus generate an "unexpected problem" in the future as well as it shrinks the range of applicable solutions. Under the category of "future problems" all the issues (that should be understood here as challenges and opportunities) requiring a medium-long term to be dealt with are considered. Such problems may consist of expanding technological application or decreased availability and adequacy of water resources (e.g. emerging contaminats). Different types of problems require different kinds of actions. Analysing in detail the relation time-action, at the lowest threshold the smallest the required degree of change in the organizational routine to respond to a problem, the faster will be the capacity of an organization to respond to a problem (Figure 8).

The operational level of an organization is able to respond to a dilemma most rapidly at (the blue line with the highest increasing slope), however the degree of the change from an initial to target state is the smallest, which underlines a transformation only in the way of doing something without affecting the other tiers of an organization. At the highest threshold, the decision level is able to respond to a dilemma with a large change in magnitude, but the latter requires a longer period of time to occur (the green line with a smaller slope). Furthermore, such change will have a chain effect requiring thus a modification both at the management and operational levels.

Nevertheless, it worth to notice that each response given by organization to a dilemma and the following change in one of the organizational levels (operational, management, and decision) has to be assessed against the uncertainty degree of. De Marchi et al. (1993) identifies in thier work different

types of uncertainty, such as scientific, social, legal/moral, institutional, proprietary and situational. The latter that can be considered as the summary of the different types of uncertainty, plays a critical role being related to the need of acting under conditions of limited and in general insufficient information to support a decision. Therefore, it is critical within an organization not only to recognize the different uncertainties to be managed in order to be aware of the possible interrelations among the different types, but also to select which is the best organizational level to respond promptly to a dilemma.

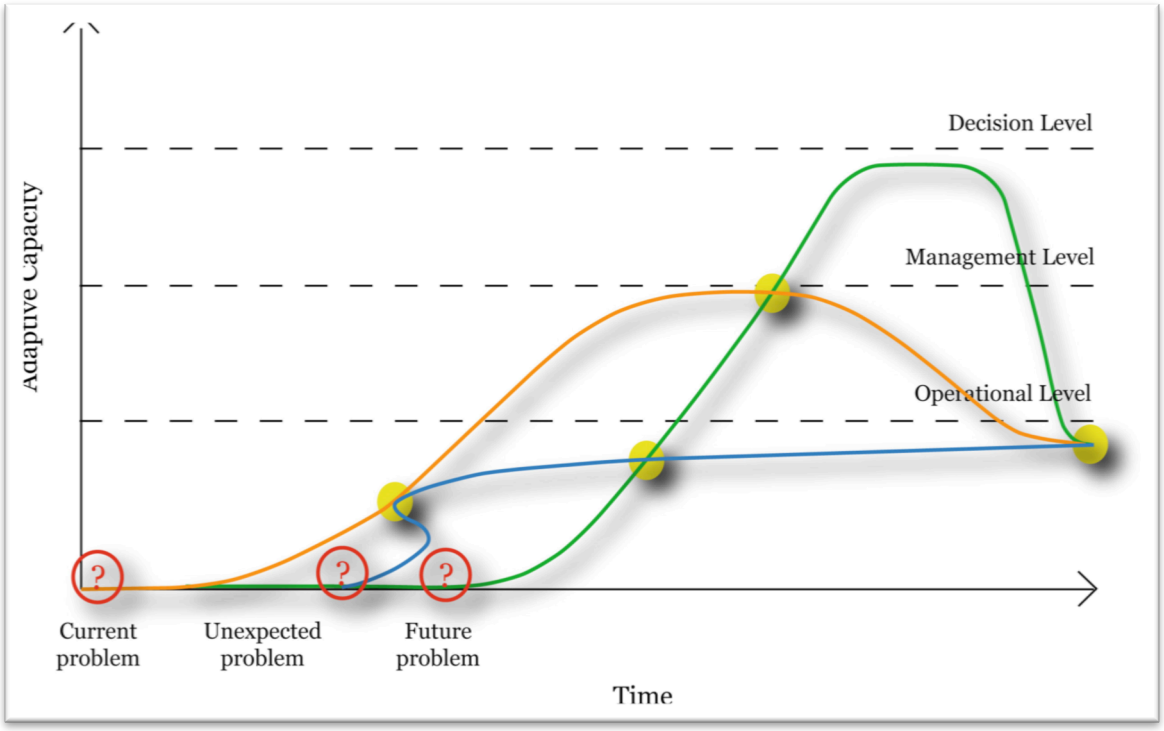

Figure 8: Relation between adaptive capacity of an organization and time (source: Author)

5.11 Constraints and challenges of the research

As this study has not being funded by a private or public institution there are not constraints defined by an external group. The main constrain of this study is the two years research time in the three years PhD program. The methodology of the study has been designed to be able to conduct the research in two years period. One of the main challenges faced during the study is to achieve all the necessary information from related institutions and key persons also due to

corruption requests personally experienced, which traced a clear and a really well defined edge in the level of free access to information.

5.12 ETHICS OF THE STUDY

Before conducting interviews to public and to relevant bodies, the detailed information of the research has been shared with them and their consent to participate in the research has been asked by the researcher. The participation of the participant is voluntary and they gave their consent to participate in the research.

CHAPTER 6: BOLIVIA CASE STUDY

6.1 WATER IN BOLIVIA

Bolivia has abundant freshwater resources, but the distribution and access are not equal and they reflect geographical differences, which characterized the country (Water for People, 2006; World Bank, 2004; Earthtrends, 2003; FAO, 2000). Agriculture is the sector using the largest quantity of water, roughly 81% of extracted water in Bolivia it is used for agriculture (USAID, 2010). Notwithstanding, only 11% of the agriculture surface use irrigation systems delivered through canal and ditch systems, providing food security to one third of the population. Further lack of access to safe water affects barely 40% of whole population and within this context differences between the percentage of urban population who cannot access to water and agriculture ones, respectively 10% and 56%, can be highlighted (WHO and UNICEF, 2004).

Bolivia has scarce systems for water distribution as well as for disposal and treatment of grey water and solid wastes, which causes environmental damage through contamination of both surface and groundwater (FAO, 2000; Water for People, 2006). Hence, water quality is affected by high levels of waterborne disease as a result of poor management of mining and hydrocarbon extraction, agro-toxins, pesticides, and solid waste.

Competition for water use and distribution has increased, specifically between the demands for domestic use versus agricultural irrigation due to rising urban and peri-urban populations. Besides, significant imbalances in potable water distribution exist between wealthier enclaves and those that are poor and populated by indigenous people (World Bank, 2006a; EC, 2007).

6.2 WATER BY LAWS

After a long and conflicting process show in the movie “Tambien la Lluvia” (released in 2011). The movie is an excellent illustration of the long conflict

started in 2000 by the city of Cochabamba opposing the water privatization process. In 2009, water has been recognized as fundamental right to life by the new State Constitution (section 373). The same section declares: "*water resources [...] cannot be object of private acquisition as well as its provision*". Further, the section 374 of the New Constitution of the State, approved on the 25th January 2009, asserts "*It's a duty of the State to manage, rule, protect and plan the adequate and sustainable use of water, including social participation and the guarantee of the access to water for all inhabitants*". Privatization of hydrological resources is not allowed, though the section 309 of the Constitution states that "*the administration of basic services related to drinking water and sewage directly can be carried out by public,* communitarian, cooperative or mixed enterprises" (GOB Constitution 2009).

The current legal framework governing water is characterized by a large number of rules, which are contradictory and where rights are not always clearly defined. Water resources are regulated by the general law regarding specifically the water resources, the 1906 Water Law (Ley de Dominio y Aprovechamiento de Aguas), which has been partially abrogated and provisions are assorted in more recent legislation, including the Environmental Act, the Mining Code, the Electricity Act, Water and Sanitation Services Law, the Irrigation Law, and the Hydrocarbons Act.

Attempts to issue a unique legislative text regulating water resources management have been unsuccessful to date (World Bank, 2006a). As highlighted by Castrillo (Castrillo et al., 2006) one of the major problems for an integrated water management in Bolivia is the institutional legacy management system which is still focused on the regulation of uses for each single sector of consumption, such as agriculture, energy and domestic. Furthermore, there is a lack of appropriate planning mechanisms regulating water uses among different groups of interest.

6.3 Introduction of the study area

The Municipality of Tomave belonging to the Quijarro Province (Potosí)

(Figure 9) is located in the Southern Altiplano region of Bolivia, which is an extensive plateau located at an altitude that ranges from 3600 to 4100 meters above sea level. The low rainfall rate distinguishes significantly this region from the central and northern highlands. Furthermore, the presence of the Uyuni Salt Flat with a surface of 12 500 km2 defines many of the ecological aspects of the area. The area is characterized by an arid climate, with extreme temperatures that range from -11°C to 30°C. The number of frost nights is 160–257 per year and precipitation is 140–250 mm per year.

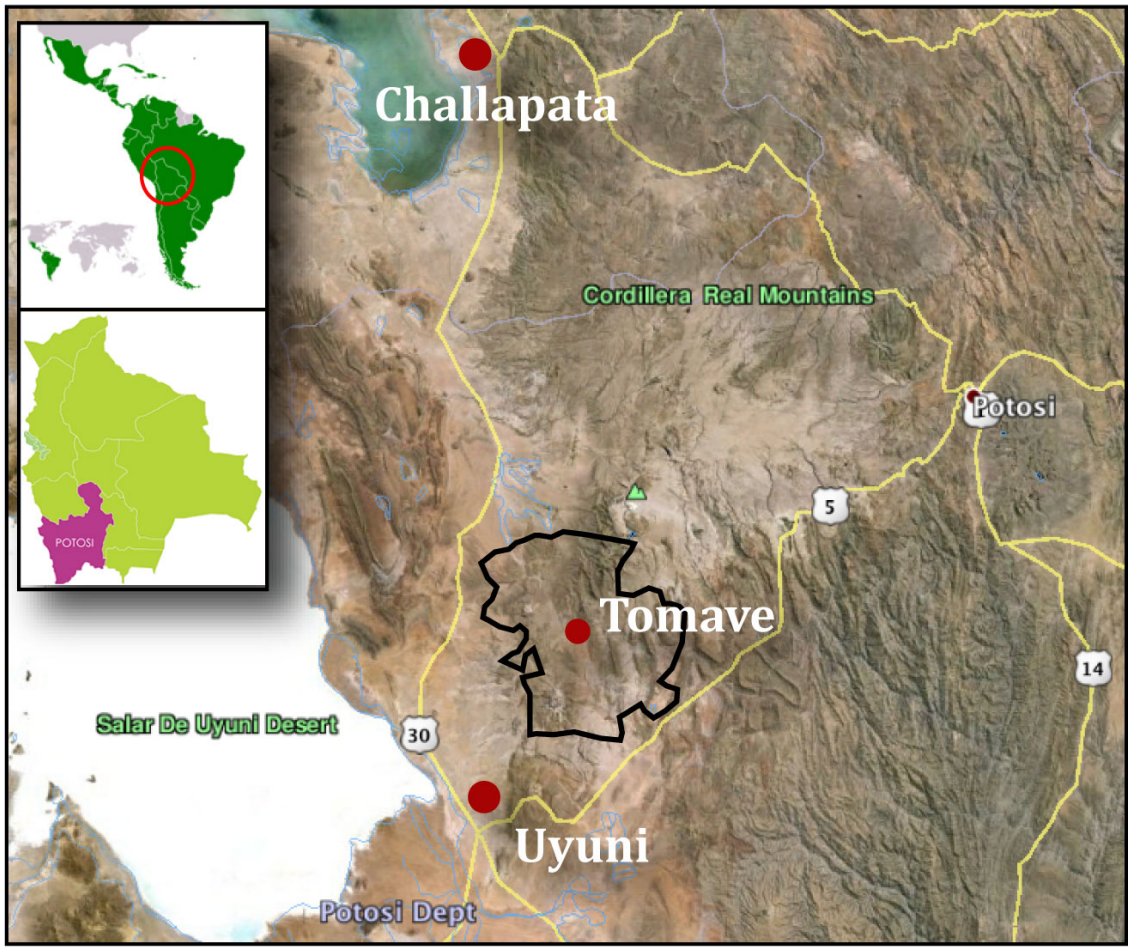

Figure 9: Municipality of Tomave (Potosi) – Case Study area

The Municipality of Tomave is composed by 11 cantons where 12,764 people live. Its economy is mainly based on breeding livestock and lamas, which represent the largest cattle (47,820) within the whole province, and on agricultural production for both consumption and sale. In turn, in recent years there has been a steady increase in the vicuñas population (that is a wild camel

living in this area). There is no exact data about it, but it is estimated that they are more than 10,000. These animals are increasingly gathering down from the mountains to the prairies inhabited by lamas.

6.4 Analyses the impacts on the socio-ecological system of past drought events

The drought crisis that occurred in the 1982-1983 was one of the heaviest in Bolivia. Studies carried out by the National Institute of Statistics and based on information from the Departmental Development Corporations estimate that 1,585,686 people in rural areas were affected by drought impact in 7 departments, including the district of Potosí. An area of 380,000 km2 was affected, slmost 90% of the Altiplano, 70% of the valleys and 10% of the lowlands (PNCC, 2007). The Emergency Committees Reports hold that as a consequence of soil erosion farmers located in the district of Cochabamba, Potosí and Oruro lost between 80 and 100% of their production. Losses were concentrated in the agricultural production as a conseguence of soil erosion. Low food availability due to over consumption of seeds leads to a situation of foos insecurity. Moreover, according to a study by the Andean Development Corporation (CAF), El Niño 1997/98 caused a loss of US$530 million in Bolivia (equivalent to 7% of national GDP), 53% of which consequent to the droughts in the Altiplano and 47% from the floods in the North and East (Oxfam, 2009).

In 2003, adverse weather conditions (hail, drought and flood) caused economic losses in the Potosí district affecting 17,756 families and 13,712 hectares cropped with quinoa, potatoes, cereals and beans. In turn, in 2008 recurrent drought and flood events affected 16 provinces, 32 municipalities, 640 Communities, 23,734 families causing the loss of 3,916 cattles as well as 24,465 hectares cultivated with quinoa, potato, bean, corn, onions, wheat.

In 2009, recorded events of drought, hail and flood, affected 14 provinces, 25 municipalities, 304 communities and 11,026 families. Moreover, a loss of 10274 ha cultivated with quinoa, corn, potato, bean, wheat, fruit and cereals, and a loss of 7,769 head of cattle lost was recorded.

During the year 2010, the District of Potosí suffered a series of adverse natural phenomena such as prolonged drought, hail, frost, flood, hurricane, affecting 16 provinces, 31 municipalities, 286 comunities, and 11,381 families (Figure 10). The impact of the natural phenomena mentioned above during the year of 2010 affected widely the economy of the department, especially in agriculture, producing the loss of different types of crops such as quinoa, potato, bean, maize, barley, wheat, vegetables and fruit (UGRP, 2010).

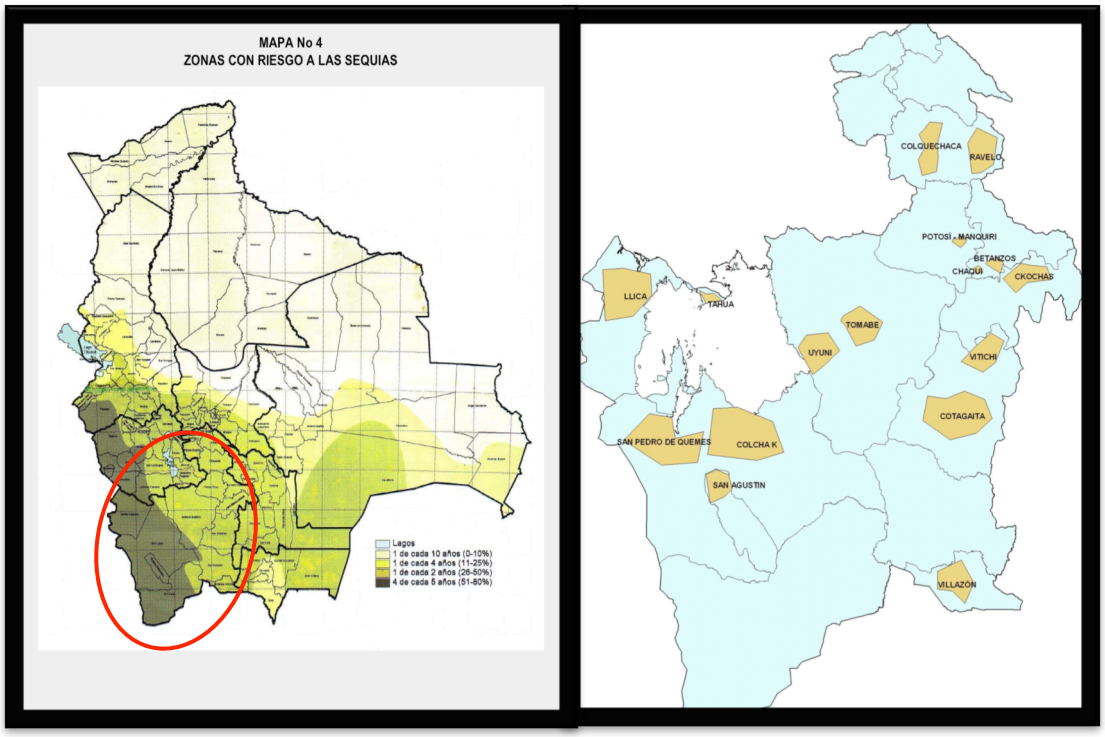

Figure 10: Drought risk area in Bolivia (left); Drought event in the Potosì District in 2010-2011 (right) (Source: Emergency Plan of the Potosì District)

6.5 Climate Change and its actual direct and indirect effects

The Bolivian population has been always exposed to extreme hydro-meteorological and climate variability, due in particular to the influence of El Niño (ENSO), which, regardless of climate change, affects different areas of the country (World Bank, 2010). According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), arid and semi-arid regions are particularly sensitive to possible decreases in rainfall. The IPCC (2007) estimates that temperatures increase in South America will on range between 1.8°C -4.5°C. Although the evidence of climate change in Bolivia is still little

studied, available documents on climate change in the area point out: a) scientific observations, b) scarcely systematized local perceptions, and c) generated according to climate models characterized by high levels of uncertainty. A study of the National Climate Change (PNCC, 2007) reports the temperature rise in the Andes from observations on the incidence of malaria in highland communities. Besides Vuille & Bradley (2000) and Francou et al. (2003) observed a clear relationship between the melting of glaciers and El Niño events with a consequent temperature increase. Moreover, in a study related to the impacts of climate change on the rainfall trends in Bolivia, Seth et al. (2010) identifies a decrease in precipitation in spring (September-November), which would affect the water resources. This trend is coherent with what has been observed by a study conducted by the Ministerio De Planificación del Desarrollo in collaboration with the Viceministerio de Planificación Territorial y Medio Ambiente based on the Normalized Difference Vegetation Index (NDVI) showing a reduction between the months of September to October and increase of precipitation in November highlighting a shortening of the rainy phase PNCC, 2000). The IPCC (2007) adds that the increase in atmospheric temperature has led to an acceleration of glacier retreat in the Andean region, with consequent impacts on water availability and the generation of hydroelectric power. According to Ramirez (2001), higher temperature increase in the coming years will affect considerably the Andes. This statement is sustained by a recent report regarding the effects of the melt glacier phenomenon on the communities living in the Bolivian Altiplano (Agua Sustentable, 2010).

Life in the Andean mountains is harsh owing to extreme climatic conditions, the most common risk factors being drought, floods, frosts, hail and saline soils. More severe and extreme climate events during the next years, with serious impacts on food production and food security are expected (Easterling et al., 2007; Stern Review, 2007). Interviewes carried out in little villages in the southeast of the Potosí district and stories told by some local storytellers suggest that farmers perceive a change in climate in the last twenty years. Table 9 summarizes which phenomena they have been noticing and their impacts on water availability in this area. Moreover, in some villages in this part of the

district, due to higher temperature farmers are cropping vegetables or wheat that they could not cultivate only 15 years ago. Notwithstanding, they state that the risk to loose the harvest is now higher than before.

Climate	Water availability
Stronger and continuous wind	Reduced river flow. Before the river rose its flow when it was windy or cloudy in the headwaters
Lesser number of rainfall events	
Increasing in quantity and duration of continues frost days	Reducing the flow of the springs
Lower temperature	
More drought events.	
Delay in rainy day	
Less snow events	
Hailstorm	
Less snow events	Reduction in the volume of flow
Delay in rainy day	
Lesser number of rainfall events	
Stronger wind	

Table 9: Climate change phenomenon and their impacts on water availability

Agriculture in the department of Potosí is mainly based on climatic variables. In other words, because farmers and communities do not have any water storage system their production is strictly linked to precipitation, hence agriculture is very vulnerable to droughts, frosts and almost completely unprotected against hailstorms (Lordemann and Aguilar Salas, 2009). In turn, such variable climate often leads to less agricultural output and therefore higher, or more volatile, food prices. Furthermore, the semi-arid mountainous areas are highly vulnerable to the disruption of local hydrological patterns and the higher temperatures could have a major effect on the central role of bofedales (a wetland located in the Andean mountains and considered a native prairie with permanent moisture), which play a key role in regulating local water supplies by releasing water during the dry season. The permanent snow that existed until 20 years ago now only remains for a period of 3-4 months. In addition, the river flows are increasingly falling and allow the cultivation of grass and legume, which could not be ripen in these areas until some years ago. The drought is accentuated from October to December and it is regular until January (ACRA

and ARCCA, 2004). A reduction both in the amount of available water and in the number of bofedales is likely exacerbated by the lack of management strategies, information on climate change and institutional constraints. In the area of Potosí, the rural poor are often subject to political and economic marginalization and ignorance that leave them with few options to improve their livelihoods.

6.6 Facing Drought: The Early Warning System as a first response

It is often possible to provide early warning of an emerging drought due to the characteristics of such natural hazard. This information allows for a shift from reactive to proactive hazard management and represents a change in focus from disaster recovery to disaster prevention, which has not been accomplished and could be instead vital in Bolivia and particularly in the Potosí district.

A survey conducted by ISDR Platform for the Promotion of Early Warning discovered that early warning systems for drought are more complex than those for other hydro-meteorological hazards and are consequently, relatively less developed globally (ISDR, 2007). Augmenting forecast and early warning information with decision support capabilities to provide information regarding options for reducing vulnerability to drought enhances local coping capacities and provides an important mechanism for reducing drought risk. Promoting the inclusion of indigenous or local groups in drought monitoring and early warning systems is essential for developing appropriate local drought indicators, verifying the occurrence of drought, and communicating the warnings to local populations.

6.7 Early Warning System in the Potosí Department

With reference to the case study, in 2009 the Potosí district developed an Early Warning System which provide hydro-meteorological information regarding the probability to have a natural or human induced disaster, which may impact on a

Municipality, a region or the whole district, in order to be able to face such event in an organized and appropriate way. The Drought Early Warning System of the Potosí Department is based on three levels (FAO Bolivia, 2009).

The first level is composed by the institutions that generate information through monitoring points (weather stations or others) that are in various communities in the department. This level includes the National Service of Meteorology and Hydrology (SENAMHI) that monitors the weather conditions of the department. The second level is represented by the Departmental Monitoring Centre, which belongs to the Department of early warning system, implemented within the Risk Management Unit of the Prefecture. This unit is responsible for the reception and dissemination of meteorological and hydrological information as well as of disseminating the degree of alert to departments and municipalities. The third level is made of the users of the System Department of Early Warning System, Municipal Early Warning, communities, to the Prefect and to the Mayor, according to the law 2140, for the activation of operation centres (EOC's) at the Departmental and Municipal level.

This early warning system has been applied to crop-graze production in various municipalities in the Potosí district. Such system combines expert knowledge with local knowledge (COMPASUR, 2011). The former is embodied in ten weather-monitoring stations that check: a) weather temperature; b) precipitation; c) wind. Furthermore, through 120 stations widespread in areas dedicated to quinoa farming the susceptibility to wind erosion and the soil humidity are evaluated. The local knowledge is based instead on forty-three bio-indicators divided in three categories: 1) vegetation; 2) animals; 3) climate and stars that are checked along the entire year. Although such system should be considered rather advanced, the interviews accomplished in May of 2012 with two different quinoa farmer associations (ARPAIAMT and SOPPROQUI) and people living in the communities located in this area show that the reliability of the system is quite low. The negative evaluation is due to two main factors. On one hand, the low level of trustability of the National Service of Meteorology and Hydrology (SENAMHI) and of its forecast; on the other hand, farmers ignore the existence of an early warning system. Hence, farmers prefer to cultivate their crops only according to their ancient knowledge even though as declared

by the "Curaca por ayllu" (the maximum authority of a indigenous community) of El Asiento (a village in the southern part of the Potosí district) during the interview "nowadays, such ancient knowledge is not so reliable anymore because of climate change animals and plants are no more acting in the same ways." Therefore, the farmers' point of view concerning the early warning system is clearly in contrast with the view of the regional government representatives, who consider the system as rather efficient.

6.8 The Bolivian Water Management

From the "War for water" of Cochabamba to water as human right

After a long and conflicting process show in the movie "Tambien la Lluvia" (released in 2011). The movie is an excellent illustration of the long conflict started in 2000 by the city of Cochabamba opposing the water privatization process. Once the war ended up, in 2006 the Ministry of Water was created so as to reach an agreement among different organizations. Although today the name of the governmental institution has changed (currently, Ministerio de Medio Ambiente y Agua/Ministry of Environment and Water), its water policy defined and detailed in the National Basin Plan (in Spanish, Plan Nacional de Cuencas - PNC) is still the same. Nine years after the Cochabamba Water War the new State Constitution (section 373) recognizes water as a fundamental right to life. The same section declares: "*water resources [...] cannot be object of private acquisition as well as its provision*". Further, the section 374 of the New Constitution of the State, approved on the 25th January 2009, asserts "*It's a duty of the State to manage, to rule, to protect and to plan the adequate and sustainable use of water, including social participation and the guarantee of the access to water for all inhabitants*". Privatization of hydrological resources is not allowed, although the section 309 of the Constitution states that "*the administration of basic services related to drinking water and sewage directly can be carried out by public, communitarian, cooperative or mixed* enterprises" (GOB Constitution, 2009).

6.9 ACTORS INVOLVED IN THE WATER MANAGEMENT

The water sector is organized through institutional structures acting at the national, regional and local levels. The main organizations in the Bolivian water management are:

National Actors

Ministry of Environment and Water (Ministerio de Medio Ambiente y Agua - MEV)

In 2009, the government created the Environmental and Water Resources Ministry, which assumed the authority and responsibilities of the Ministry of Water (established in 2006 in response to harsh popular reaction against private water companies in 2000 and 2005). This Ministry includes the Vice-Ministry for Biodiversity, Environment, Climate Change and Forest Development and Management. The *Ministry of Environment and Water (MEV)* is an organization based on a decentralized approach. It serves as a communicator and facilitator of policies and information dissemination even though it has a hierarchical organization with multiple autonomous entities. This is managed by community level organizations at the local level. With reference to this, The Ministry of Environment and Water whose strategies of action are rooted on the Water Law of 1906, the Institutional Framework Regulation Act of 2004 (D.S. 28817) 5, and the Irrigation Law 2878 of 2004, has to be held consultation with the technical and social advisory group of civil society organizations and the Consejo Interinstitucional del Agua (CONIAG), which is sort of a intersectional stakeholder forum.

The MEW "*develops and implements policies, standards, plans, programs and projects for the conservation, adaptation and sustainable use of environmental resources and irrigation development and basic sanitation with integrated watershed approach, preserving the environment, which ensures priority use of water for life, respecting traditions and customs to live well*[19]" (MMAyA 2011). In detail, along with the Vice Ministry of Water Resources and Irrigation (VMWRI), the MEW oversees the formulation and approval of irrigation

[19] see: http://www.mmaya.gob.bo/."

development policies, regulations, plans and programs, and in coordination with the board of directors of Servicio Nacional de Riego (SENARI) manages the national financing and international financing to promote irrigation development.

Vice-Ministry of Potable Water and Sanitation (Viceministerio de Agua Potable y Saneamiento Básico - VMPS)

The objective of VMPS (S.D. 29894/09) is to implement drinking water (potable water, sanitary sewer, composting toilets, solid waste and storm drainage) and basic sanitation as well as manage funding for investment to allow full access and expansion of services, particularly in rural and urban sectors and peri-urban low-income areas, and coordinating with the appropriate bodies, within the integrated management of water resources and solid waste.

Vice Ministry of Environment Biodiversity and Climate Change (Viceministerio de Medio Ambiente y Cambios Climáticos – VMEBC)

VMEBC aims to regulate, plan and oversee the integrated management of natural resources and environmental quality in order to to increase the quality of life of the population. Such object should be achieved within the framework of sustainable development and under the philosophy of living well while reducing poverty. It is in charge of implementation and administration of the National Environmental Impact Assessment (SNEIA), National Environmental Information System (NARS), and the National Environmental Quality Control (SNCCA). Furthermore, it should Work towards projects that achieve the implementation of preventive measures and adaptation to climate change.

Vice Ministry of Water Resources and Irrigation (Viceministerio de Recursos Hidricos y Riego – VMWRI)

The Vice Ministry of Water and Irrigation (VMWRI) established in 2008 was developed as a tool for information management sector under the National Irrigation and Watershed Plan. The VMWRI has adopted an integrated water resource management (IWRM) plan through Bolivia's National Plan for Watershed Management (Plan Nacional de Cuencas (PNC), 2006,). Such plan contains strategic and political guidelines for the social, economic and ecological management of water resources.

National Irrigation Service (Servicio Nacional de Riego - SENARI))

SENARI with its departmental irrigation services (Directorios Departamentales de los Servicios Departamentales de Riego, SEDERI), was established as an independent agency currently under the Ministry of Environment and Water by the Law 2878 in October 8, 2004. SENARI is strengthened with administrative and management powers and has the responsibility to execute and coordinate with the various bodies at national, departmental, municipal, local and watershed activities for the development of irrigation. Moreover, its duty is to regulate, plan, manage and promote public investment in irrigation development, agricultural and forestry production.

Local Actors

Municipalities

A set of law (Popular Participation No. 1551, the Municipalities Law No. 2028, Law No. 2066 of Provision of Water Services, Potable and Irrigation Act No. 2878. 9 states that municipal governments hold administrative jurisdiction over water and sanitation services. According to the Law of Popular Participation, municipalities are responsible for the provision, operation and maintenance of water services and sanitation in their jurisdiction.

Regantes (the decentralized irrigators and local decision makers)

Bolivian irrigators or Regantes, decentralized irrigators come into prominence after the protests against neo-liberalization of resources mainly the 'water wars' and the 'gas wars' (Perreault, 2006; Perreault, 2007), have influenced the institutionalization and hence governance of water resources. Irrigators are acknowledged as legitimate partners in negotiations with the state, the private sector, and donor agencies. Their legitimacy arise from their successful campaign for a Irrigation Law that was passed in 2004, which critically involves them as stakeholders in – a seemingly – transparent and participatory process of water governance. In essence the irrigator rights movement strengthen the legitimacy of civil society actors and effectively worked towards and filled the "hollowed out" state of Bolivia where, anti-neoliberal, culture-based, decentralized and interconnected network of peasants have successfully re-configured the geometry of power and politics in natural resource governance (Perreault, 2008).

Ancient indigenous agreements

In indigenous zones, community water use and management is usually based on customary practices and governed by elders and traditional leaders (Table 10) within an ayllu. An ayllu is a typical Andean form of extended family community region characterized by having a common -real or perceived- descent and that works collectively (called "*ayni*") in an area of common property (Machicado, 2012).

Name	Function
Curaca por ayllus	He is in charge of protecting the territory and knowing the population who is in charge of.
Jilacata	He is in charge of collecting property taxes and visits the families of his ayllu.
Corregidor	He is responsible of ensuring the welfare and the development of the Municipality as well as to enforce the laws.

Agente municipal	He is responsible for enforcing livestock damage to crops, cemetery management, rodeo donkey.
Comisionado	He is in charge of notifying communications for assemblies, meetings,etc.
Junta escolar	He is the responsible of watching over education issue and its management.
Registro civil	He is the responsible of issueing birth, death and marriage certificates.
Presidente Asociación comunal	He is in charge of maintaing communication with ARCCA, AZCCA organizations and partners.
Juez mínima cuantía	He has the role to deal with families' requests by fulfilling rules and rights.

Table 10: Description of the different roles in an Ayllu

6.10 DECISION-MAKING AND WATER ORGANIZATIONS

The organizations in the Bolivian water sector are multiple and complex. Decision-making organizations are mainly governmental institutions even though they are strongly influenced by very-active stakeholders such as societal actors, non-governmental organizations, and donor agencies. The civil unrest following the 'water wars' and the indigenous rights movement has left an indelible institutional memory and is often cited by decision-makers as the pivotal moment for organizational reform, which has contributed to the organizational diversity seen in present days. Bolivia's legislation governing water is incomplete, out-dated (the National Water Law has not been revised since 1906) and falls short in clearly stating user rights. In addition, Bolivia has attempted with popular participation to create a new law to govern water resources, but has been unsuccessful to date (World Bank, 2006a). In this context, the *Ministry of Environment and Water* (MEW) is one of the most powerful ministries in the Bolivian cabinet. The MEW has grown rapidly into a network of national, regional, and local entities, whose representatives have various means of providing their input to policies devised by MEW.

The Consejo Interinstitucional del Agua (CONIAG) serves as the 'forum' where MEW encourages disparate participation thereby representing the socialist electorate and constituents of the President Morales. Ministers and Vice-

Ministers of MEW routinely make decisions while balancing the needs of a multitude of stakeholders. This challenge of balancing needs is frequently played out in ministerial budgets, external support, and leadership changes. Thus, decision-making at ministerial level of MEW is highly political and less technical, thereby rendering decisions that are conservative, risk averse, and dependent on the dynamics of the political landscape. The vice-ministries of MEW – VMWRI, VMEBC, VMPS and the independent irrigation agency SENARI present similar albeit nuanced differences in decision-making. The vice-ministries are implicitly hierarchical in political and socio-economic priorities as evidenced by the number of projects and budgetary allocations under each vice-ministry. However, all decision-makers acknowledge the importance of potable water and climate change issues irrespective of their hierarcal level across different ministries. Because irrigation is considered as one of the primary development goals of Bolivia and is supported by extensive financial support by internal and external agencies, VMWRI is not only important to external donors but also to the decentralized irrigators. The decision makers in VMWRI are thus highly visible political leaders and managers whose actions are closely followed by electorate and NGOs. The visibility of Bolivian water managers stems from several intricated connections and often-conflicting issues. Bolivian water sector plays host to several issues not uncommon in water management such as frequent problems in water supply and sanitation, powerful irrigation lobby groups and electorate, rise of water-intensive mining activities, and exploding urban population. Visible effects of climate change in the form of receding glaciers and recent political upheaval riding on the political momentum created by the social unrest due to commercialization of water contribute to the attention that MEW and VMWRI receive. In addition, the fact that water issues reflect and have become a symbol of a) indigenous rights, b) societal inequality and c) portrayal of Bolivia as a victim of developed-country emissions, critically shapes the politics of water management. The VMEBC has seen several organizational changes. Once a powerful ministry itself, the VMEBC has been reduced to a vice-ministry whose decision-making capacities are now subsumed by the MEW. Decisions in VMEBC follow technical guidelines and the Bolivian constitution.

Lastly, the *Regantes* or the community irrigators are part of a National Water Service (Servicio Nacional de Aguas). These institutions were formed in 2003 after a series of irrigator's workshops to raize awareness on water rights and livelihoods threatened by privatization of natural resources during the water wars (Perreault, 2006; Perreault, 2007). As mentioned above, the focus of the Regantes is primarily securing peasants rights for irrigation, and drinking water and sewerage not only in rural Bolivia but also in urban areas. The establishment of the SENARI, the SEDERI's codified under the Irrigation Law of 2004 is a result of proposals by the irrigators when they achieved the legal recognition and protection of their *uses y costumbres* for water rights and management (Perreault, 2008). Decision-making amongst community managers is inclusive and representative of community needs. Typically, community meetings, which are held frequently, serve as the basis for decision-making where a community-elected Board of Directors makes decisions on water access and use. These decisions often reflect irrigator's needs. Managers make decisions based on: a) individual area under irrigation b) equity among community members, c) availability of water, and d) seasonality.

6.11 TOWARDS A NEW WATER MANAGEMENT APPROACH

Since the 1990s Bolivia has taken decisive steps towards the establishment of a decentralized administrative system, based on a model that claims responsibility to local demands and assign to municipalities power to take decisions and plan at the local scale. Since 1994, the number of municipal governments increased from 25 to 327, with a corresponding increase both in administrative revenue and local investment (Ruiz and Gentes, 2008). Furthermore, departments have more political power in the decision-making process since the departmental prefects are elected directly by the people (Ruiz, 2005). In this context, the Bolivian National Developing Programme recognizes the basin river management and the Integrated Water Resource Management (IWRM) approach as processes that promote a coordinated development between water, land and related resources to maximize social and economic equity in order to guarantee the sustainability of vital ecosystems (MDP, 2009).

In the same period, the laws in force attribute to local governments the responsibility of water services, local sewerage, and the management of micro irrigation infrastructures. Furthermore, the existing institutions identify the departmental governments (prefectures) as the key authorities to operationalize and implement environmental policies and the IWRM (Ruiz and Gentes, 2008). In this context, the National Basins Plan (Plan Nacional de Cuencas (PNC) of Bolivia approved in 2006, has been developed on three pilars: the Integrated Water Resources Management, Integrated Watershed Management (MIC), and the Social Management of Water and Environment in basins. These pillars are considered necessary and complementary. According to the PNC, the Integrated Watershed Management is understood as a set of actions leading to sustainable use and exploitation of natural resources of the basin. Originally, the scope of MIC was oriented towards treating water catchment areas, while today it is associated with spatial planning issues, regional development and integrated environmental management. Actions should be aimed at improving the quality of life of the inhabitants of a watershed (Cooperación Alemana, 2010). The third concept that the PNC adopted is the Social Management of Water and Environment in basins, which refers to a participatory decision-making system and to the implementation of new social measures related water use and management, based on a continuous development of knowledge and learning across different social groups, which allows them to influence the processes of decision-making at the political level. Thus, this approach aims to emphasize social participation in the water management.

6.12 Water Management and the indigenous farmers community

The law (CPE. art. 403) a “Territorio Indigena Originario Campesino” (Original Indigenous Rural Territory) (TIOC) set the rules for: areas of production and exploitation, areas for the preservation of natural resources and areas for social spiritual and cultural reproduction. The new Constitution of the State (CPE) states the right to land to indigenous comunities, the exclusive use and the exploitation of renewable natural resources according to the conditions determined by law (Fundación Tierra, 2011). Furthermore, it recognizes the

right to be informed, consulted and to participate in profits coming from the exploitation of non-renewable natural resources that are in their territory. Indigenous comunities have the right to apply their own rules, to be administered by their structures of representation and to define their way to develop according to their cultural criteria and principles of harmonious coexistence with nature. Moreover, social organizations (mainly indigenous and farmer organizations) managed to ensure both within the Constitution and the watering law the respect of the uses and customs of the indigenous peoples with reference to self-determination, access to water and natural resource. From an interview with the NGO Agua Sustentable (Cochabamba, June 2012), it become cleat that such intention germs from the will to avoid any possible abuses of large users (industries, mining sector, companies providing municipal water), which in the past have pressured to privatize water.

The term “water rights” in the indigenous farmers communities refers to a set of rights, which undoubtedly emphasizes the right to use and access to channels and other sources, but also the right to participate in decision-making on water management, admission of new users (e.g. migrants) and alienation of third parties (in the form of sanctions or limitations). Such right, use and access to water of family, for example, is defined by his participation to rituals, celebrations and community activities (Gerbrandy and Hoogendam, 1998). Irrigation systems in Andean indigenous communities are systems of "collective action" (Boelens and Davila, 1998). Access to and use of water require collective agreement and work because isolated individual cannot manage and maintain irrigation systems efficient because of their complexity. In these irrigation systems there are “ayllu”: families who have the right to use a portion of the water, and to participate in collective decision-making process. Thus, in the indigenous farmer management the right to water is an individual or family right within a system of collective decisions. Individuals or families can claim the use of part of the water, but they cannot decide on its use in time and space without previous arrangements with other users. Hence, water is not seen only as a natural resource because it embeds also social aspects and therefore water cannot be considered a private good (interview with NGO ACRA Bolivia, October 2012). Users, such as the head of the family, may have the right to

participate in the making-decisions process or be elected as "Alcalde de agua" (in Spanish, water Mayor), the authority in charge of planning works of maintenance, controlling water distribution between families and holding a meeting to discuss community issues and decide sanctions, if necessary. To keep the right to access and use water, farmers must do some works, such as maintaining and cleaning canals of irrigation as well as roads that pass through their territory.

6.13 THE WATER SYSTEM IN THE MUNICIPALITY OF TOMAVE (POTOSÍ)

Water in the urban settlements

In the rural area of Tomave, water to people living in villages is provided by two different systems: piped distribution system delivering water to 1671 houses located in a village (44.8%) (Figure 11); and "mingitores rusticos" (wells) serving 685 houses located in a village (18.3%); people not living in villages extract water mainly from streams (36.1%) or "ojos de agua" (springs) (Table 11).

TOMAVE						
		1992			2001	
Houses	**Total**	**urban**	**Rural**	**Total**	**urban**	**Rural**
Number of Houses (Viviendas)	4861	0	4861	5014	0	5014
Number of Houses (Hogares)	3150	0	3150	3726	0	3726
Services		0			0	
with kitchen and bathroom	175	0	175	221	0	221
with kitchen or bathroom	2363	0	2363	2877	0	2877
no kitchen and no bathroom	612	0	612	628	0	628
Water source		0			0	
Piped	627	0	627	1671	0	1671
Tank truck	18	0	18	0	0	0
Well	551	0	551	685	0	685
Stream (or surface water)	1945	0	1945	1346	0	1346
Other	9	0	9	24	0	24
Water Toilet drainage						
drainpipe	29	0	29	23	0	23
septic room	6	0	6	17	0	17
Other	172	0	172	229	0	229
No toilet	2943	0	2943	3457	0	3457

Table 11: Housing Conditions in Tomave (INE - Statistic Municipalities Atlas, 2005)

Figure 11: Houses and water services in Tomave (source: Author)

Irrigation systems

Users participating in the realization of irrigation works consider then an investment in terms of labour, intellectual contribution, fee, meetings, etc. The duties concerning the cleaning of water channels and maintaing the routes are directly linked to support the development of community life, and the irrigation system too (Figure 12 and Figure 13). There is thus a close relationship between the water management and the other social functions. People belonging to an indegenous community do not meet and interact only as irrigators but also, and sometimes primarily, as relatives, neighbour, co-owners, etc. (interview with NGO ACRA Bolivia, October 2012). In addition, such different interrelations between users highlight the necessary flexibility required in the implementation of duties and penalties associated with noncompliance with the local legal regulations.

Figure 12: Water transfer for irrigation (source: Author)

To grant the water right to a family or individual, the community determines whether he is meeting its duties and functions. In case a user does not comply with its obligation to clean the channel or make up for his wage or ignores the recommendations of the "Alcalde de agua", he may be sanctioned with the suspension of water, but never forever. However, the application of sanctions is not rigid. It depends on a collective decision and there is considerable tolerance between members, hence failure is rare. At times and as extreme and final solution, if someone cannot replenish his wages or cannot be substituted by anyone, he may be authorized to cancel his duty providing the sum of 20 Bolivianos which corresponds to 2,10 € (Interview had with the Curaca of El Asiento (Chikoka Chico), June 2012). Therefore, one of the fundamental principles in the Andean irrigation system is the continuous process of creation and interpretation of rights in terms of development, adaptation and rehabilitation of the system (Boelens and Davila, 1998).

Analyzing in details the irrigation system, it is evident that all communities in the Municipality of Tomave use irrigation systems to crop (Table 12), however during my fieldwork it was possible to notice that there several problems related to water loss or inefficient use (such as, losses due to runoff, practice of night irrigation) and to polluted water due to mining activities.

Figure 13: Reservoir in Tomave (source: Author)

Ayllu	Name of Community	Irrigation System	Notes
Chikoka Chico	El Asiento	30% of plots are irrigated by floodplain irrigation throug distribution channels, 20% use drop-by-drop technology and 50% use a rainfed system.	Water distribution systems through open channels for storage and pipeline distribution system to plots (sprinkler).
Chikoka Chico	Chiutaca	95% of plots are irrigated by floodplain irrigation throug distribution channels, whereas 5% use a rainfed system	
Jila Chico	Saruyo		There are dams that provide water to the communities, so that there are agreements for cleaning and maintenance at the level of Ayllu.
Jila Chico	Uracaya		There are dams that provide water to the communities, so that there are agreements for cleaning and maintenance at the level of Ayllu.
Tawqa Grande	Suntura	The same the river supplies water for irrigation	In the area of wetland, there is a thermal water spring.
Tawqa Grande	Ventilla	They exploit part of the river flow for irrigation through distribution channels.	
Chikoka	Tomave	100% of their vineyards have a floodplain irrigation system and water is distributed to plots through channels.	There is a moderate amount of water in the groundwater and emerge from springs or hot springs.
Sillsawa	Totora “K”	Plots are irrigated through a channel distribution system.	
Aransaya	Sivingani	Plots are irrigated through a channel distribution system or rainfed.	
Q´hasa	Opoco	Plots are irrigated through a channel distribution system	
Q´hasa	Carlos Machicao	Plots are irrigated through a channel distribution system.	
Q´hasa	Jachioco	Plots are irrigated through a channel distribution system or rainfed.	There is a lake - La Kaluta - not very deep, which is in danger of extinction.

Table 12: Irrigation systems used in the different communities (source : Author)

Water resources and hydropower

There are rivers that are contaminated by activities carried upstream by the use of lubricants in hydroelectrical power generation (Kilpani Hydropower Plants, Landara and Punutuma) (PDM Tomave, 2008) directly affecting the amount of availability of water for agricolture20 and other uses.

6.14 The Bolivian quinoa market: impacts of global market changes on rural-urban resilience

Quinoa, a grain-like crop farmed primarily for its edible seeds, has been one of the main ingredients at the base of the Andean farmers' diet for thousands of years. According to the indigenous land use management of the Southern Bolivian Altiplano, quinoa were placed on bare slopes and hillsides in order to protect the plants since its production area is characterized by low rainfall, presence of sandy soils, saline and eroded, recurrent drought, frost and high winds and sparse vegetation, while plains covered by shrubs were dedicated to grazing activity. Traditionally, the cultivation of quinoa was aimed at auto-consumption (Lidema, 2008) and the whole production process was conducted manually according to a well-defined methodology, which prescribes to leave the land uncultivated for a long time. Such fallow period, around one year, has different purposes, such as restore soil fertility after harvest, and reduce the probability of disease. Although the most relevant reason is to store water in the soil in order to sustain quinoa production which require 2 years of precipitation during its growth period (Joffre and Acho, 2008). This process requires at least 10 years due to the slowness of biological processes at this high altitude (Joffre

[20] *"En cuanto al municipio Tomave hay dos plantas de electrificaciones que están afectando al campesino. Más antes casi no había tanto, no se notaba, porque había nomás agua, pero en estos tiempos el agua se está disminuyendo y en ese canal donde está Chillpani y Punutuma se lo sacan todito el agua y por el río de donde tomaba el campesino no hay, no hay agua de dónde sacar. No nos da justicia tampoco nos escuchan, dos veces ya se ha levantado el campesino contra esta empresa y se va levantar siempre porque no se va a dejar así tranquilo, entonces en cuanto a estas dos empresas, en la empresa Chillpani, casi no hay sembradíos si no hay mojicales donde multiplica animales y ahí viven y ahora los mojicales se están secando no hay agua, ahora en Punutuma son sembradíos todo y se están secando, toda esa gente se iba a la Argentina, la mayoría, pero ahora están regresando como ahí la situación esta muy difícil, ahora si que necesitamos trabajar la tierra pero no hay agua"* (Bustamante, 2002).

and Acho, 2008). However, nowadays, the role and the strategies to cultivate quinoa have changed completely. This crop is currently a product sold globally, 90% of the total quinoa production in Bolivia is now exported (Bolivia Rural, 2010), and this is due mainly to the popularity reached by natural and organic products, to be suitable for gluten-resistant population, and for a production free of fertilizers and pesticides. In 1986 FAO defined quinoa as a strategic food for the Andean region and numerous articles were published on the national and international press about quinoa as highly nutritious food causing great interest in food demand in the United States, Canada, Europe, Israel and Brazil. In 1991, during the "First Regional Meeting on Plant Genetic Resources", La Junta de Cartagena, the actual International Plant Genetic Resources Institute (IPGRI) and the Inter-American Institute for Cooperation on Agriculture (IICA) recognized quinoa as strategic crop catching the interest of American and European consumers, as food "exotic and healthy".

Bolivia is currently the largest producer and exporter of quinoa in the world, with 46% of the world market and this allows Bolivian traders to define, to a large extent, the price of quinoa internationally. In the regional fairs of Challapata located in the Department of Oruro, as in the Desaguadero, on the border with Peru, where the interdependences between international cities networks and global commodity chains fully appear, the international prices of quinoa are determined. In detail, in these markets interact simultaneously registered exporting companies (basically buying certified organic quinoa) to export quinoa legally and not registered traders whose purpose is to export to Peru. The latter handles larger volumes of quinoa (perhaps up to 50% more than the registered exporters) since Peruvian buyers acquires all the qualities of quinoa even broken or very small grains, thus they are able to influence the pricing process of quinoa (MDRyT y CONACOPROQ, 2009). In the end, prices set for quinoa at Challapata market influence the price paid to the producer. The price of quinoa sold by the farmer has almost tripled from 1999 (USD 862.8/t) to 2008, up to USD 2.306.2/t (MDRyT y CONACOPROQ, 2009). This is three times the price of soybean and five times the price of wheat (La Razon[21], 29 September 2009). As consequence quinoa has affected many Bolivian farmers.

[21] Bolivian National Newspaper

Thus, a quite clear trade-off can be identified by an increase in the farmers annual income, between 55 and 85% of families' income living in Oruro and Potosí department is indeed due to the quinoa sold to the market (CAF, 2001), at the cost of a remarkable spread of the cultivation imposing a relevant transformation in the land use in the countryside, in the lamas farming and in the social behaviour. Consequently, farmers prefer selling it and buying less nutritious food for themselves (Hellin and Higman, 2005).

6.15 Direct and indirect impacts of cropping quinoa on water resources

As we have seen earlier, the Southern Altiplano is affected by a gradual decline in water availability due to the intensification of adverse weather effects in the area (drought, low rainfall, high winds) (Jaldín Quintanilla, 2010). Despite this, the rising price of quinoa is pushing producers to an extensive and unsustainable exploitation of soil and water due to a widespread and intensive one-crop agriculture in favour of the quinoa's export. Furthermore, local ecological knowledge has in the last decade tended to be displaced with the shift from subsistence livelihoods to more market-dominated regimes with mechanised production systems (Sillitoe, 2002). Therefore, to take advantage of the use of tractors the cultivation of quinoa is extended to plains reducing the area covered by vegetation, which here acts as windbreaks. Its destruction affects directly the superficial water resources due to an increase in the amount of superficial water carried away by the constant winds present in the area and it favours soil erosion leading to a severe degradation of soil fertility (PIEB, 2009). Because of the expansion of the agricultural frontier and the decrease of water, fodder availability is decreasing (Felix and Villca, 2009), thus, as I have noticed during my fieldwork, lamas seeking for food have been starting to access to the quinoa fields and "bofedales" (wetlands) (Figure 14). Bofedales are ecosystems rich of vegetation and they act as water resources storage in this region, and this area due to their characteristics are prone to impacts of the current overgrazing for cattle. Furthermore, it must be added that such wetlands are extremely fragile ecosystems and they are already greatly affected by new climatic phenomena that determine a loss of the "fields of snow and ice",

which determines, in turn, a gradual decrease of water and moisture, preparing drought events. Besides this, such condition is exacerbated by the growing number of vicunas whose protection and management are regulated respectively by “Convenio para la Conservación de la Vicuña”, revised in 1998, and D.S. n° 0385/2009, which are competing with lamas for food.

Pareja Ampuero (2010) reports in his study that: ”areas apparently are progressively dried or drier; this coincides with widespread reporting of water gradually decreasing in the region, coincident with the reduction or disappearance of snow and ice fields in the last two decades. All people I have consulted with agree on a drastic reduction in the availability of the water compared to previous years (Figure 15). In contrast with this, there are two main factors. On one hand, there is a high pressure to convert grazing pastures in areas of cultivation of quinoa, mainly due to high international prices and also to ANAPQUI (Asociación Nacional de Productores de Quinua (in Spanish), National Association of Producers of Quinoa), which pays well for the production of quinoa. On the other hand, while participating at the meeting between the evaluator of the European project and community leaders and members, I noticed from the discussions and maps drawn by the different communities (Figure 16, 17, and 18) that there is, on the one hand, a general willingness especially within the younger generations to enlarge the agriculture frontier only by applying more organic agriculture methods, to guarantee water availability by increasing the protection or restoring *bofedales* in order to be able to provide supplemental irrigation to their crops when needed, to diversify more their revenues (e.g. someone refers to tourism or to sell handcrafted products at the market). However, I must add that the work done by the NGO ACRA, as confirmed during informal chats with communities members and leaders, generally increased the environmental awareness of people, in particular in the Ayllus of Jila Chico, Khoza, Tauca y Chicoca. Nevertheless, quinoa production is already unbalancing those ancient indigenous agreements because farmers respect them less and less, in particular those individuals coming back from cities to their communities are not interested at all in taking part to meetings (Dorian, 2009) and doing any kind of collective work, such as cleaning water channel systems used to irrigate. They prefer to pay, not

performing their duty and their action is having the effect of discouraging other community members to follow the ancient rules.

Figure 14: Overgrazing in a bofedal in the Municipality of Tomave (source: Author)

Figure 15: Direct and indirect impacts of cropping quinoa in Tomave (source: Author)

Figure 15: Direct and indirect impacts of cropping quinoa in Tomave (source: Author)

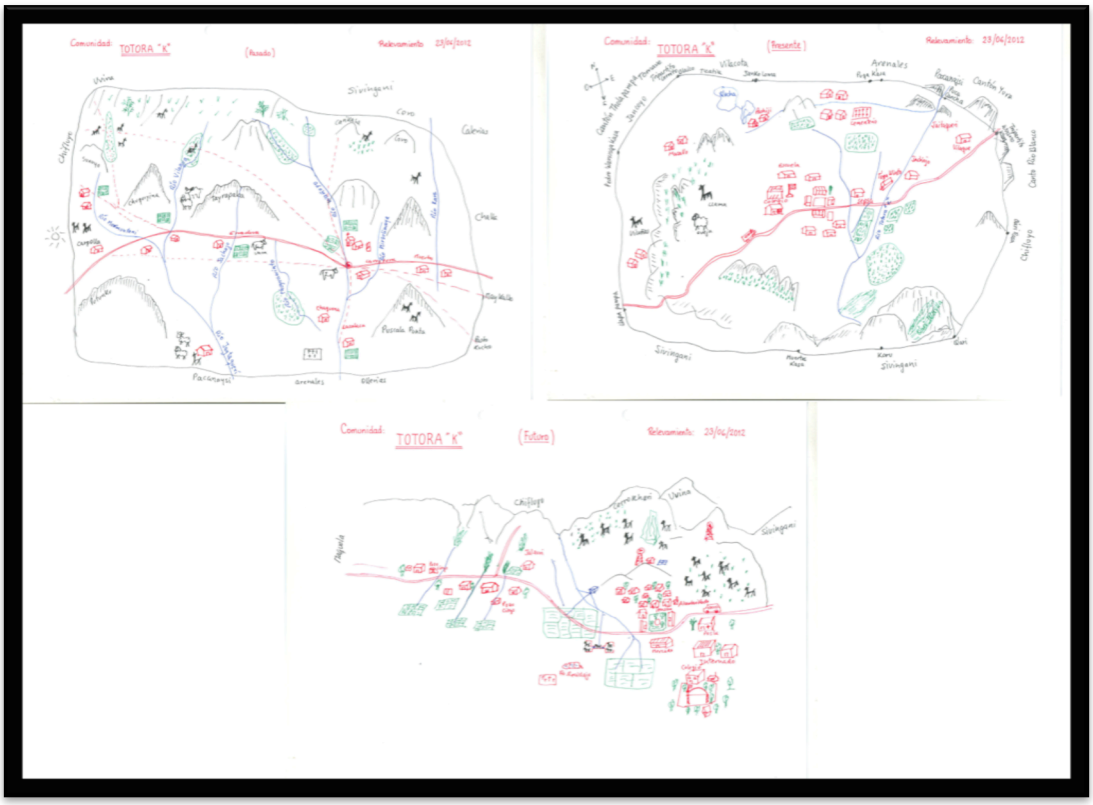

Figure 16 : Description of the territory belonging to the indigenous community of Opoco

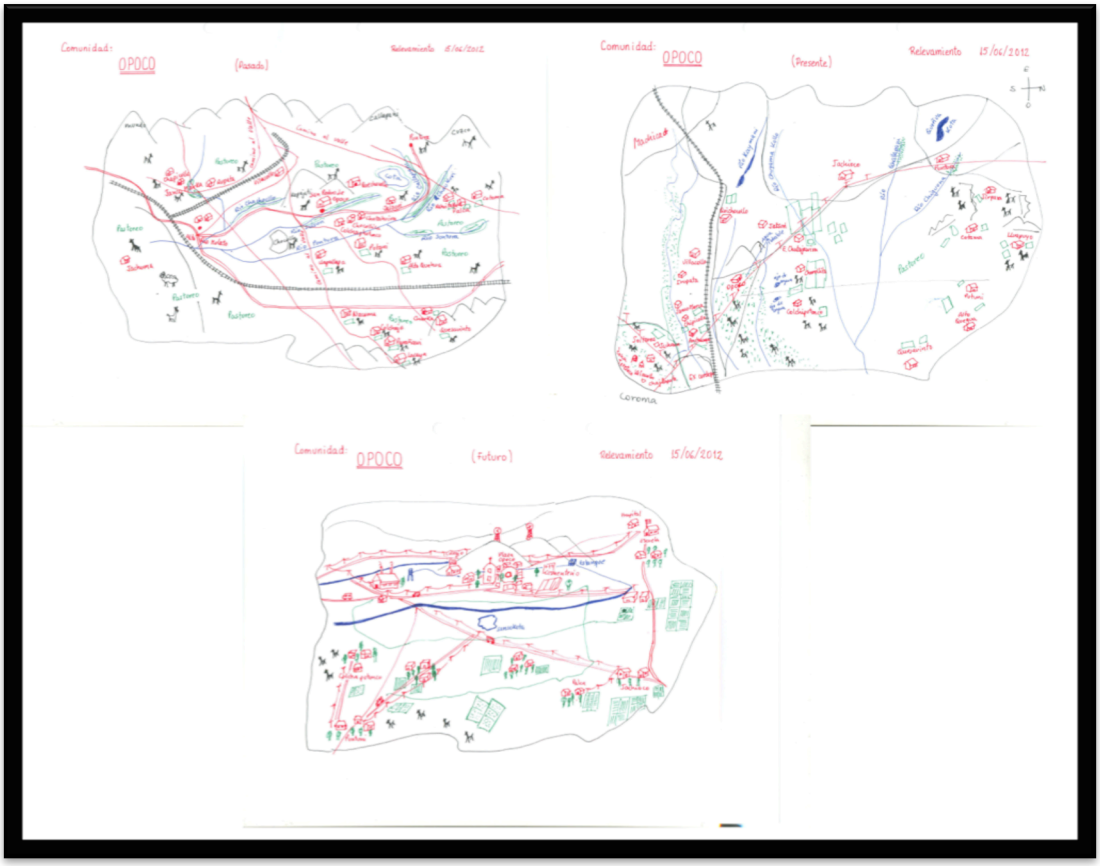

Figure 17: Description of the territory belonging to the indigenous community of Totora K

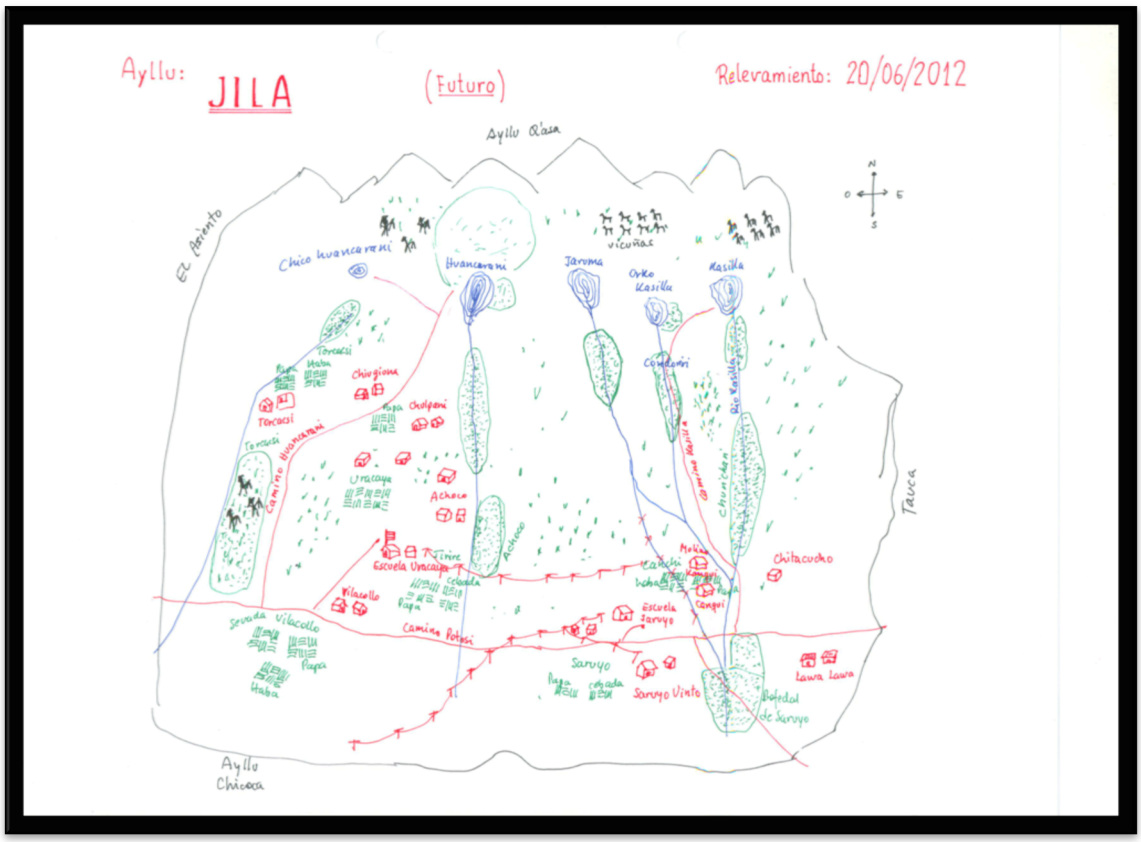

Figure 18: Map drew by the Indigenous community of Jila in the Municipality of Tomave

6.16 TRADE-OFFS IN THE BENEFITS TO RURAL SYSTEMS

The increasing urban population (more than half of the global population lives in urban areas (UN, 2011) requires a growing amount of resources to satisfy its needs. Consequently, to meet to such demand, the velocity and the number of global interconnections are rising at a speed never seen before and are modifying the traditional view of the rural-urban nexus (Seitzinger et al., 2012; Young, 2006). The connection of urban regions to globally dispersed areas of terrestrial production is exemplified by the global links between plant production (e.g. food bioenergy supply, etc.) and the places where the resource are consumed (Erb et al., 2009). Furthermore, urban metabolism and ecological footprints of cities provide another approach to analyse the effect of urban-rural relations. However, such connections are not having an impact only on land uses, but are determining a set of cascading effects. On one hand, the implications on the water resources used to produce the food are shown by Dalin et al. 2012. On the other hand, such connections to satisfy the increasing

urban consumption impacts on society and the environment (Seitzinger et al., 2012). Adapting to the global market changes resulted in unsustainable changes of the agro-sustainability at the regional scale. In line with the Panarchy model (Folke et al., 2010), adaptation at one scale may result in transformation at a lower one. Therefore, this case study gives a good example of how cross-scale interactions and drivers may produce real trade-offs in the benefits to rural systems. The resilience of agricultural systems is defined by the capacity of the region to adapt to external changes in order to maintain satisfactory well being of the population, while balancing ecosystem, economic and cultural functions of those rural regions (Heijman et al., 2007). The important point is that if ecosystem, economic and cultural functions are jeopardized; the overall system resilience is compromised. Crop production is a key aspect of rural resilience (Wilson, 2010; Heijman et al., 2007), but if ecological resilience, or underlying biological diversity, is undermined, so too will be the resilience of the entire agro-ecosystem (Clergue et al., 2005). In this case, the urban-dominated shift in system functioning generates a mixture of benefits and risks for the resilience of the system – increased well-being for local farmers, but undermining wide-scale rural resilience. A key outcome of this cross-scale trade-off is that the onus for maintaining resilience of the agro-ecosystem falls on local actors. As market demand is not strongly linked to local ecological carrying capacity, decisions for sustainable development and avoidance of over passing critical ecological thresholds rely on dialogue between local farmers and the urban market administration. The uncontrolled migration from towns to quinoa farming lands is another pressure that is exerted locally from this cross-scale interaction. Sustainability concerns and the responsibility (and opportunity) to manage these trade-offs may lie with local people (Lauer et al., 2013), but by critically evaluating the vulnerabilities and opportunities that occur through such cross-scale interactions because of global consumption chains and urban demands, urban systems have an important part to play (Grimm, 2008).

6.17 Barriers to a water management paradigm shift and institutional traps

Although nowadays the time of the "War for Water" and the social conflicts surrounding the privatization seems to be far away, Bolivia is facing today new challenges posed by the adopted water management system and discussed in section 6.11. The main concern does not refer anymore to water as a human right; it is related to the need to take measures aiming at overcoming inefficiencies due to inadequate policy and institutional frameworks, which act as barriers to the implementation of water management and to the enhancement of the related decision-making processes. With reference to the new Bolivian water management, four main barriers can be identified: (1) institutional legacy; (2) fragmentation; (3) corruption and Elites pressure and; (4) lack of tools.

1. Institutional Legacy

The current Plan National de Cuencas (PNC) states that the basic unit of planning and management of water resources and environment is the basin, which relates the spaces of public management and social. The basin is considered a living space, around which systems should be established integrating water resources and basin management, prioritizing human consumption, agricultural production, the needs of flora or fauna and other social practices, productive and economical (Ministerio del Agua, 2006). However, as highlighted by Castrillo et al. (2006) one of the major problems for an integrated water management in Bolivia is the institutional legacy management system which is still focused on the regulation of uses for each single sector of consumption, such as agriculture, energy and domestic. The current legal framework governing water is still characterized by a large number of rules, which are contradictory and where rights are not always clearly defined. Water resources are regulated by the general law regarding specifically the water resources, the 1906 Public Domain and Water Use Act (Ley de Dominio y Aprovechamiento de Aguas) (Consejo de Ministros, 1906), which has been partially abrogated and provisions are assorted in more recent legislation,

including the Environmental Act, the Mining Code, the Electricity Act, Water and Sanitation Services Law, the Irrigation Law, and the Hydrocarbons Act. Attempts to create a single law to govern water resources have been pursued but unsuccessfully to date (World Bank, 2006b). One of the main achievements derived from the Water War was the Law 2066/2000 on Drinking Water and Sewerage (Agua Potable y Alcantarillado), which was signed with the agreement of the government and social organizations. The law aims not only to redefine the competencies regarding drinking water and basic sanitation of different entities, but also to guarantee the right to water for indigenous and peasant communities and the water supply to urban slums. Thus, it assigns greater control to the Superintendency of Basic Sanitation and municipal governments. Despite of this, the current government, led by Evo Morales, president of Bolivia since 22 January 2006, intends to create a policy framework, which expressly prohibits the privatization or concession of water and its services (Ministerio de Medio Ambiente y Agua, 2009). Thus through the Supreme Decree 0071/2009, the Water Supply and Sanitation Taxation and Social Control Authority (Gaceta Oficial de Bolivia, 2009) replaces the Superintendency of Basic Sanitation. Up to date, the General Water Act and the Law on Water for Life (Agua para la Vida) have not yet been approved. Therefore, the law 2066 is still in force. Furthermore, as an anticipation of the regulatory changes expected in the future, the government has changed direction where water management is concerned with the Basic Sanitation Plan 2008–2015 (Ministerio de Medio Ambiente y Agua, 2009). In addition, the National Procurement Law (1178/1990) establishes eligibility project condition that are difficult to meet for many of the local governments also because of unclear division of responsibilities (Valle de Carvalho and Angulo, 2011a).

2. Fragmentation

As we have seen earlier, Bolivia is promoting a shift in the context of water management by laws and by an institutional re-organization as discussed in 6.10. Despite institutional progresses, however, the same Ministry of Water doubts about the feasible integration of different sectors and administrative

levels arguing that "[...] the institutional framework established by different laws and regulations are not suitable to perform the Integrated Water Resource Management because there is a large number of players with powers, functions and overlapping interests" (Ministry of Water 2007, 6). Furthermore, the concept of water basin as defined in the PNC does not include any socio-political element related to the water management drawing a simplicist vision of water issue. In turn, the Bolivian Constitution (in Spanish, Constitución Política del Estado) defines four types of territorial units, such as the district, the provinces, the municipalities and the original indigenous government. With reference to such division, the Law No. 031/2010 of Autonomies and Decentralization regulates the autonomy of each level. Autonomy is conceded both to the nine departments to regions to (all) the municipalities and to Original Indigenous Government (in Spanish, Ley Marco de Autonomías y Descentralización) with the exception of provinces. A region is not a pre-defined territory, but may be comprise a number of municipalities and provinces showing cultural and historical values as reaching an agreement on such kind of controlling system. A region may be thus constituted beyond municipalities' and/or provinces' borders, but not beyond departments' ones. Consequently, it may happen that the administrative, political and indigenous borders do not match with the limits of the basin generating conflicts among the different actors involved in the water management process. Therefore, as it has been shown by different experiences carried out the construction of a system at the institutional level to facilitate the implementation of the integrated water resource management has not been achieved yet (Quiroz et al., 2012).

3. Corruption and Elites pressure

Corruption is a complex issue in Bolivia and as stated by Valle de Carvalho and Angulo (2011) and as personally experienced in some cases, it is endemic at all levels of public administration. Therefore, the inefficiency of public administration is reinforced. However, thanks the work of social organizations, the irrigation regulation and the State Constitution recognized the indigenous uses and customs usos y costumbres concerning self-determination, access to

water and resource natural (Valle de Carvalho and Angulo, 2011). Uses and customs related to water are defined as ideas, rules and traditional practices of a community or ethnic-social group. They can be sometimes unspoken and ambiguous and justify preferential access to a source through rights, privileges (Gerbrandy and Hoogendam, 1998). Although the government intention while issuing the law 2878/2004 was to prevent abuses of large users (industries, mining sector, companies providing municipal water) in the past have led to a de facto privatization of water, the constitutionalization of the customs and traditions may become counterproductive and generate more conflict if applied indiscriminately. This will have important consequences for the ability to manage the water resources of water related actors based on universal principles of public order and water governance. The concept of usos y costumbres is deployed discursively to claim irrigator water rights and cultural autonomy, but it also masks processes of differentiation within the Bolivian peasantry (Saldías, 2012). With reference to this, irrigation can be considered a term of differentiation between farmers. In the high-altitude and semi-arid Bolivian Andes, as in case of the Municipality of Tomave here described, irrigation serves to supplement rainfall, extend the growing season, and protect crops from frost (Guillet and Mitchell 1994). Even though no certain data exist, it is estimated that around 25% of Bolivian campesinos have access to irrigation systems (Interview with Professor Alfredo Duran Nuñez del Prado, Centro Agua, Cochabamba 19 June 2012), which means that the resting 75% result more vulnerable to drought, frost, and short growing seasons using only rain fed agriculture and experiencing higher rates of outmigration and poverty. Hence, the law 2878/2004, promoted by irrigators and their allies [mainly Feracion Departamental Cochabamba de Regantes (FEDECOR)] and the national irrigators' association], protects existing water rights but does nothing to promote the extension of rights to non irrigating campesinos (Saldías, 2012). In addition, the law ascribe the role of referee for new water rights petitions to SENARI whose directorate is composed by seven irrigators out of the thirteen available positions (according to the article 9, law 2878/2004), giving them a permanent majority. Therefore, in some respects the law institutionalizes the privileged status of irrigators and provides the same irrigators with the power to exclude other farmers from the use of a commons resource and thus to divert

investments and funds to satisfy their corporate's needs.

4. Lack of tools

Since 1994, when the Popular Participation Law" was issued responsibilities passed to the Municipal governments and local participation addressed through the new Territorial-Based Organisations (OTB's). OTB's are recognized as local actor in development issues and each one is entitled to an annual fund from the local Municipality for community development projects, which they plan and submit for approval. At least 20% of national tax income is now directed to municipalities (Smits et al., 2004). According respectively to the law 2028 (Ley de Municipalidades) and the Law 031 (Ley Marco de Autonomias y decentralizacion) local authorities are now facing increasing responsibilities in various areas, counting for new roles relating to services delivery (like more regulatory functions), development planning and environmental management, such as the Municipal Development Plan (Plan de Desarrollo Municipal) and the Land Use Plan (Plan de Ordenamiento Territorial). These new roles constituted a major challenge especially for rural Municipalities that before were only operating in urban centres (Smits et al., 2004). Furthermore, even tough the Popular Participation Law transfers more resources to the Municipalities through the "co-participation accounts", the process of decentralization has not always entailed a transfer of human resources and management tools (Valle de Carvalho and Angulo, 2011a). As a result the majority of local authorities, and within these there is also the Municipality of Tomave, are not ready for this new responsibility due to a lack of personnel, money and political will. Therefore, while the most of the skills related to water resources management remain at central level, the demand for "autonomy" continues to be a relevant topic in the central government agenda and it is promoted at local.

6.18 THE ROLE OF NGO IN FOSTERING ADAPTIVE CAPACITY OF ORGANISATIONS

ACRA Bolivia is an international medium size NGO working in different area of Bolivia. In details, it was developing a project[22] of Cooperation funded by the European Union in the area selected as a case study. The project ended up in July 2013, involved one thousand families, for a total of 4500 people belonging to 34 communities living in this area. It was aiming both at alleviate poverty in rural communities of the Bolivian highlands and strength the capacity of civil society organizations and local authorities in Bolivia (ACRA, 2009). Although ACRA Bolivia's project was not specifically targeted to face drought and climate change, it was promoting adaptation and building adaptive capacity in the face of a complex nexus of social, economic, and environmental stressors by helping the indigenous communities to include flexible livelihood options and by facilitating the flow of knowledge and resources between local and external scales. First, ACRA had to promote among the producers, production techniques and practices respectful of the environment and appropriate to the local context to better face desertification and future natural disasters. Sometimes this meant recovering ancient traditional practices that have been abandoned in the last decades, such as fallow land, use of slopes oriented against the wind, etc. However, ACRA Bolivia was aware that because of changing environmental patterns, traditional knowledge could help in facing it but that alone it would not be enough. One of the outcomes of NGO's project was the need to equip communities with a wider array of options to face future challenges as well as a no longer quite stable environmental context. Thus, the project was supporting the establishment of policies focused on defining production practices and rules to guarantee a sustainable use of natural and productive resources (such as co-existence of agriculture and animal breeding, etc.) through a campaign of information for local producers and authorities aiming at increasing their awareness on the current problems and related future possible impacts. And as further strategy, it was fostering alternative income resources, such as changing the way in which lamas are slaughtered (in a slaughterhouse, with high hygienic conditions, according to buyers' demand,

[22] Project ANE/2009/227-642: "Integración productiva de camélidos y quinua en Tomave" 2010 – 2012, co-financed by European Commission

etc.) in order to enrich the farmers' diet and obtain better prices on the local markets or giving the opportunity to women to produce and sell the lamas yarns increasing thus the local adaptive capacity through a multiplication and diversification of the wage incomes. As we have seen, thus, organizations can foster community adaptive capacity by building flexibility into institutions, and providing spaces for collective learning. Furthermore, ACRA Bolivia strongly promotes the participation of foreigner students and researchers in the project in order to bring in a variety of approaches and grasp information at other scales with reference to different issues and collectively share knowledge with governmental and indigenous authorities and communities facilitating therefore cross-scale and over time interactions. With reference to the foreigner people (aid-workers, students, and researchers) coming to Tomave, there is a common and shared perception concerning how differently local people and foreigner people perceive "time" and the "flow of events". This has brought all of us to compare the foreign idea of "doing" and "need to do" with the local idea of "there is time to do thing" and a sort of "immutability of things" and to think about how much such different idea of these two concepts affect the achievement of the project' goals as well as its effectiveness.

6.19 Interviews with organisations in charge with water resources management in Bolivia

Interviews with the "Curaca" of some indigenous communities, with the NGO ACRA's manager and aid-workers and with Alfredo Duran, the director of the Nationl Study Centre on Water Management, have been carried out to understand the water management context which the Municipality operates in (Table 13). These interviews have been carried out as open question interviews and they were mostly focalised on understanding the degree of network and the connectivity of the Municipality. While a semi-structured interview has been carried out with the officers of the Municipality of Tomave.

Bolivia			
No. Respondents from the institutions	Sector	Organisations	Specific Competences
1	Governament	Gobierno Municipal de Tomave	The Municipality of Tomave is the second municipal section of the Antonio Quijarro Province in the Potosi Department. This local authority represents the decentralization of central power. The municiapality develops, approves, and modifies the community development plan according to legal norms, and regional and national plans.
6		Ayllus (Curaca)	Ayllu is a typical Andean form of extended family community region characterized by having a common -real or perceived- descent and that works collectively in an area of common property. Within the ayllu, the curaca is the highest authority. His power is based on the ability to organize people in a series of tasks.
1	Third parties (NGOs, International Agency, Knowledge Institutes)	Centro Andino para la Gestión y Uso del Agua - Universidad de San Simon de Cochabamba	The Andean Centre for Water Management and Use (Centro AGUA) is a research and educational center, belonging to the Faculty of Agronomy of the Universidad Mayor de San Simón (Cochabamba).
3		ACRA-CCS Bolivia (NGO)	ACRA Bolivia was the coordinator of a cooperation project aimed at reducing poverty in the Municipality of Tomave. Within this project, ACRA recognized to its local partners a key role in designing and Implementing strategies and actions.

Table 13: Interviews with organisations in charge with water resources management in Bolivia (source :Author)

6.20 Adaptive capacity of the Municipality of Tomave

The interview had with the technicians' team manager of the Municipality revels that understanding what will be future trends in the area of Tomave is a core-theme of the Municipality's technicians of Tomave. In addition, access to information is seen as critical to both address uncertainties that are brought about by economic development and changes in climate change. In particular, technicians have the perception that the actual status of knowledge on climate change does not allow them to make sound decisions about the activities in the area in the future. Thus they are more focused on ENSO impacts on the area, which is something they are more familiar with and they experienced. From the survey, it has emerged that the ability to access data and info has increased in the last years by taking part in national and international projects and thank to the arrival of the mobile phone technology in 2010. However, the feeling among respondents is that the current ability is far to be enough also because of the low availability of hystorical and updated data, the lack of a structured database and capacity of data management. In addition, a lot of information, data and knowledge are owned by the local communities and have never been recorded or collected. With reference to this, the survey highlights how the low level of coordination and conflicts interest between the municipal government and the indigenous communities sometimes generate an ineffective situation where the exchange of information becomes complicated.

The survey showed that the capacity of the Municipality to identify as well as to fill the gaps in data and information is insufficient. Despite of this, from the survey it seems that Municipality's technicians are extremely aware of what are the effects of the current problems, which they are trying to monitor, collecting more data and information. Technicians started to identify and list causes and effects of the current problems to understand better what they have to face off, even though as stated by the technicians' team manager their capacity to work with scenarios and to identify future problems is still low. Furthermore, from the interviews, it is evident that technicians act mainly in a continuous state of emergency (low level of funds and personnel available); consequently the need to deal first of all with daily problems reduce their capacity to tackle unexpected

and future problems even when those can be clearly defined. According to one respondent, in opposition to this emergency status, there is the fact that by being a small group there is the need that everybody be aware of the different problems in order to be able to perform different tasks at the same time. Therefore, internal communication and a shared vision of the problems are considered essential to face them off. On this line, the survey underlines how the presence of national and international organizations (DELA Potosí, ISALP, DANIDA) working on technical assistance and institutional strengthening is considered as a resource by the Municipality. Nonetheless, it also emerged that the process of sharing perspectives on problems definition between the Municipality and the other organizations is not so smooth. In particular with reference to the European project promoted by the Ngo ACRA, during the interview it was possible to highlight a divergent interest between the political and technical levels. On one hand, even thought an agreement (Acuerdo Marco Regional) between the Ngo and the Municipality of Tomave was signed at the beginning of the project, the Municipality as reviled by the Councilman (Edwin Mamani) and promoter of such agreement had no interest in following the ACRA's project working lines because no money for the project were allocated in the Plan de Operaciones Anual (POA)[23]. On the other hand, instead, the Councilman and the technicians' team manager considered this European project and other current projects as an opportunity. Projects are seen as a momentum in which they can experiment, access to information individually or collectively, and bring in perspectives from outside the institutional structure. However, representatives of the technical level, interviews also emphasised a sceptical standpoint concerning the effectiveness of the solutions implemented by projects due to the encountered difficulties in the management of investments and works done within previous projects. In spite of this, the municipal government is generally oriented to respond to emerging problem in a reactive way entrusting to other institutions (mainly national or international)

[23] The POA is a instrument, which within the period of one year permits to intervene in the municipal economic resources in order to achieve the PDM. The municipal government can only accomplish projects and activities, which are inscribed in the POA Municipal and the PDM. Thus, the POA is an instrument for social control over the municipal governments activities and permits a transparent financial management (VPEPP, 2000).

the answer shared as much as possible to the emerging problems.

As results from the interview with the technicians' team manager, the Municipality has its own vision and goals identified within the Municipal Development Plan (Plano de Desarrollo Municipal) and according to this he tries to define through a participatory process solutions to tackle the different issues. However, the survey highlights that such system presents various difficulties. Some of these stem from the fact that indigenous communities try to impose their solutions and vision, even though these ideas are not representative of the whole community. For example, because a gender issue, women can barely express their ideas in order to contribute actively to define the idea of development of the indigenous community. On the other side, there is the issue of the projects proposed by national and international organizations. Each of them signs an agreement with the Municipality so to have an umbrella for their activity and pursue their own projects goals introducing their vision and solutions.

The technicians' team manager recognizes that dilemmas arise from the lack of coordination among the different organizations and the mayor's office as well as a low integration and orientation of all the implemented solutions towards a set of problems the Municipality has to face currently and will have to in the future. On this line, the survey highlights that well-known solutions are preferred and chosen because the technicians feel more confident with them, but they would like to acquire more experience in formulating actionable and manageable solutions. As in the case of the "sub-basin water management plan", first developed but then abandoned because it is characterized by long-term and sometimes costly strategies, hence it is perceived as not having clear outcomes on water resources.

As a matter of fact, the Municipality barely experiments new solutions to face old and new issues, even though the technicians are quite open to introduce innovative solutions if supported by external advices and help. The number of problems is so high that the main goal of the Municipality is focused on decreasing this number rather than on the way problems are solved or reduced. This has three direct effects on: (1) strategically (medium-long term) solutions

are seldom taken; (2) solutions often reduced room for creativity and innovation in the problem solving phase; (3) the selection of solutions characterized by being reversible is extremely rare. As stated by the technicians' team manager, mostly all the solutions they choose are taken on the base of uncertainty or incomplete information because there are no alternatives to uncertain data as well as it might be that they do not know how to incorporate information, such as climate information. They have within their decisional process. Besides this, he thinks that the current decision-making is burdened by a multitude of ambitions – indigenous, development, regional identity, and decentralized management.

As results from the interview, there is not a real monitoring process of the impacts and effectiveness of implemented solutions. However, at municipal level there are two phases of evaluation. The main assessment is carried out when the validity of the PDM (Plan De Desarrollo Municipal - Municipal Development Plan) ends and the Municipality needs to draw the new plan. In this moment, a comparison of the different data describing the past and the current situation of the Municipality takes place and it is used to orient the future goals. On the other hand, the Municipality carries out an assessment of the solutions listed in the POA, which are defined according to the PDM, annually. However, such assessment mainly refers to the fulfilment of expenses and fiscal requirements.

6.21 Barriers and Opportunity to Adaptive Water Management Implementation

As it is possible to note from Table 14, the level of adaptive capacity of the Municipality of Tomave is quite low. This is not due only to the barriers in the governance as earlier described in the paragraph 6.18, which requires an institutional reform, but also to the existence of barriers to the implementation of an adaptive water management. This underlines the need to integrate top-down and bottom-up approach in order to remove those barriers that hamper change and consequently the implementation of an alternative water

management approach.

At the national level, the Bolivian central government having adopted a new water management system acts as a main driver of change and therefore, at least theoretically, works to remove those barriers. In the meantime, donors can play a relevant role. Donors-funded projects focusing on increasing water availability are definitely important, however as highlighted also by the interviews, such projects should aim more at empowering municipalities and indigenous communities working and living in this region in order to support and help them to face current and future challenges and uncertainty in a more resilient manner.

In turn, local governments, such as the Municipality of Tomave, can play a likewise central role in accomplishing adaptive water management activities both within their boundaries and within the local and regional watersheds. Indeed, local authorities act both as regulators and as service providers and have a role in raising finance. They have both direct and indirect tasks for the water security of their communities and economy.

As results from the interview with the municipal technician's team manager, the major barriers to the implementation of an adaptive water management, which can be observed at the organisational level, refer mainly to: (1) lack of capacities about data interpretation, (2) scarce long-term perspective, (3) coordination and communication problems, (4) lack of a monitoring and evaluating process, (5) low commitment level (or fear of failure), (6) low financial resources and limited personnel.

In detail, the data collected during the interview have been summarized and assigned respectively to the related cell in table 14, applying the developed conceptual framework described in the section 5.8 (Table 14). The red cells refer to the absence of any activity aiming at building/enhancing the relative capacity, while the yellow ones mean that there is an ongoing activity or interest in upgrading these capacities; the green cells show that the organisation already has some adaptive capacity to respond to the related dilemmas. The grey cells, instead, mean that it was not possible to collect data regarding such capacities or the amount of information collected is not sufficient to assess the

organisational adaptive capacity.

What/when		PROBLEM FINDING			PROBLEM SHAPING		PROBLEM SOLVING				DECISION TAKING		
		Variety of problem frames	Capacity to collect and manage data	Capacity to predict problems from collected data.	Capacity to understand and outline the dilemma's borders	Proactivity	Diversity of Solutions	Clear mechanism for enforcing rules	Preventing rigid persistence	Institutions capacity to inform about their decisions and of the procedures to implement them.	Responsiveness	Monitoring and evaluation	End-user oriented language
LEARNING CAPACITY (organisational)	Ability to deal with everyday and crisis situation												
	Willingness to experiment												
	Institutional memory												
	single loop												
	double loop												
	triple loop												
	Trust												
LEARNING CAPACITY (individual)	Willingness to change and to adapt												
	Preparedness to experiment												
	Continous access to information												

What/when		PROBLEM FINDING			PROBLEM SHAPING		PROBLEM SOLVING				DECISION TAKING		
		Variety of problem frames	Capacity to collect and manage data	Capacity to predict problems from collected data.	Capacity to understand and outline the dilemma's borders	Proactivity	Diversity of Solutions	Clear mechanism for enforcing rules	Preventing rigid persistence	Institutions capacity to inform about their decisions and of the procedures to implement them.	Responsiveness	Monitoring and evaluation	End-user oriented language
SHARING AND NEGOTIATING	Availability of the data to others												
	Connectivity												
	Degree of network												
	Multi-actor; multi-sector; multi-level (Vertical and Horizontal)												
	Ability of an institution to communicate and debate ideas and solution to problems among different agencies												
LEADERSHIP													
CAPACITIES	Human reources												
	Financial resources												
	Technological resources												

Table 14: Assessment of the organisational adpative capacaty of the Municipality of Tomave (source: Author)

It is questionable given the low organisational adaptive capacity if (current and future) risks will be effectively addressed. However, the level of organisational adaptive capacity and thus the capacity of the Municipality to face the different challenges will not increase without taking any action.

Clearly, not all necessary reforms can be done at the same time. Therefore, it is essential to define priorities and a sequence of activities to fulfill those priorities. According to this, Lee (1993) writes that institutional and organisational challenges may be a key barrier to the implementation of adaptive management, but at the same time that an adaptive management approach may be a tool for enhancing institutional and organisational effectiveness. As follows, even though there is a low level of adaptive capacity and changes have not been implemented yet, the Municipality of Tomave acknowledges that they need to advance.

The opportunity for the implementation of an adaptive water management in the Municipality of Tomave is paradoxically provided by the failure of the water management mechanism to meet the many challenges described in section 6.14, 6.15, and 6.16.

Within this context, adopting an alternative water management system would probably mean on the one hand enhancing the level of coordination and cooperation both between the municipal government and the various indigenous communities; on the other hand increasing the coordination between the different indigenous communities and the municipality to be considered as a fundamental node in the network. As follows, enhancing cooperation and coordination can create a window of opportunity to: (1) increase the level of participation in the decision-making process involving standpoints more oriented towards a long-term perspective, such as those of younger generations and; (2) design a common vision of change the needed path of and according to this implement the defined actions, thus reducing trade-offs and conflicts. With reference to this, generating a vision should facilitate consensus and commitment within the organisation itself and among all stakeholders. Moreover, defining and having a broad consensus in goals and values would guide organisational change. Linked to this given the current

environmental change occurring in this area, it would be necessary to take a problem-focused approach, which means considering droughts and water related problems not as sectoral issue, but rather working at the boundaries among system and organisations. This would attach the reform processing to the need to solve concrete problem. Such approach may help to mobilize people and organizations around common goals giving them the incentive to participate in reform processes and enact changes. In addition, this would keep reforms pragmatic and action oriented sweeping reforms and designed solutions that are not implementable, as in the case of the sub-basin water management plan.

The activation of a "process of consultations" would favor the integration between indigenous and "expert" knowledge, increasing therefore not only the data available about water but also generating wisdom[24]. Indeed, introducing new institutions based on generalized principles may be rejected by local people as costly, illegitimate and awkward (Cleaver, 2002). Furthermore, Merrey and Cook (2012) underline how traditional or indigenous institutional measures should not be idealized either because such arrangements are "often highly inequitable (for example disempowering women), unable to adapt to rapidly changing conditions driven by population growth, climate change and new technologies, and may also be losing legitimacy because of growing ineffectiveness". With reference to this, it is worth noting that participation can marginalize the poor or vulnerable (e.g. women) even more further if the mechanisms are bached by a stronger, such as richer, advocacy group.

Furthermore, the process of consultation would enable learning by doing and thus facilitate organisational learning in contrast to normal practice. In this line, for instance, water policies now focusing only on blue water can be integrated with policies oriented to the use of the green-water[25] resources, which is part of

[24] Wisdom refers to Data-Information-Knowledge-Wisdom (DIKW) Hierarchy (Cleveland, 1982), considered as the canon of information science and knowledge management. In the water sector, the Global Water Partnership refers to wisdom as *agreement about commonly accepted methods of using water resources to ensure sustainability*. (www.gwp.org/en/ToolBox/TOOLS).

[25] Green-water resource is the precipitation on land that does not run off or recharges the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation (e.g. moisture in the soil). Eventually, this part of precipitation evaporates or transpires through

the traditional indigenous agricultural practices to crop quinoa in this area. In addition, the process of integration of knowledge would allow the Municipality not only to learn but also to take the risk of making mistakes, and would foster the stakeholders' sense of ownership in the needed changes. Such ownership is essential for sustainability.

Moreover, as we have seen in paragraph 6.21, new technologies (mobile phones) are giving further chances to get more information, in the meantime further significant opportunities can come through other technological resources, such as internet, and pave the way to build up a network of municipalities aiming at data exchange, experiences, and advices. Networks are indeed instrumental in developing shared understanding of a problem and aid in the formation of common objectives by defining the discourse (Raustalia, 1997), and by leading on learning and the development of innovative ideas (Sendzimir et al., 2007; Pahl-Wostl et al., 2010)

Besides this, the implementation of an adaptive water management has to envisage also the integration of water and land use regulations especially regarding the bofedales system (see paragraph 6.15) because of the strategic role that these wetlands play in this region during dry periods. As follows, there is the need to redefine or develop new community sanctions and the way these are enforced since the current regulations are scarcely effective.

plants. Green water can be made productive for crop growth (although not all green water can be taken up by crops, because there will always be evaporation from the soil and because not all periods of the year or areas are suitable for crop growth). [Hoekstra et al., 2010; Falkenmark and Rockström, 2006]

CHAPTER 7: MOROCCO CASE STUDY

7.1 WATER IN MOROCCO

The World Bank has called Morocco a "champion [of water policy] in the MENA[26] region" (World Bank 2008) because of different factors, such as: development of water laws, decentralization of water management, public-private partnerships in water development, and demand-side policies. Notwithstanding, Morocco experiences severe water problems as a result of irregular weather conditions and high frequency of droughts (Bennis and Sadeq, 1998). When droughts occur because of a growing population, and a current inadequate freshwater supply groundwater is over-used leading to saline intrusion and water quality problems (Diao et al., 2008; World Bank, 2008).

19% Morocco surface is covered by arable land, 40% of the population relies on agriculture as its primary source of income. Agriculture is thus responsible for nearly one fifth of the GDP (Diao et al., 2008).

In response to an increased occurrence of droughts in the late Eighties and early Nineties the government passed the 1995 Water Law that recognized water as a public good and rationalized water management in the country. For most of the 20th century Morocco's water policy agenda has been to expand access to water by building the infrastructures (Tsur er al., 2004). As a consequence, Morocco's irrigation network is well developed, and it has a storage capacity of 16.1 cubic kilometers (World Bank, 2008; FAO Aquastat, 2005).
At present Morocco's priorities have shifted towards improving water supply and sanitation as well as looking for new water sources. Since it has already tapped most of its potential water development options, Morocco is now investing in projects for wastewater re-use (Choukr-Allah, 2010) ensuring that the use of treated wastewater complies with heath quality standards. Also desalination is increasingly considered as an action to meet rising levels of water demand, in particular in the interior areas. Desalinisation in those areas is used to improve the quality of brackish groundwater to make it suitable for drinking (Saadi and Ouazzani, 2004).

[26] Middle East and North Africa

7.2 WATER BY LAWS

In 1912 the law issued by the Protectorate marked a turning point in the legal system with the introduction of a "modern" juridical concept: water as a public right. In continuity with the legal framework for water introduced in 1912, the current "Code de l'Eau" (Water Code), Law n° 10-95 was issued in 1995. By law water management has been decentralized; integrated management and rationalization of water use for meeting the needs of all users concerned has been introduced (ISKANE, 2009).

The Law n° 10/1995 identifies the Hydraulic Basin as the unit for the development and implementation of local integrated water management plans, which, in turn, contribute to the development of the National Water Plan. Furthermore, in 1999 Hydraulic Basin Agencies were established fostering the implementation of recent trends in water management. Additionally, through the introduction of the polluter pays and the user pays principles, the new law provides the means to finance protection and rehabilitation of water bodies. Other relevant laws and regulations concerning environment and water resource protection are: the Law 31/2000 for the development of sewage services; the Law 11/2003 on the protection and the enhancement of the environment in Morocco; the Law n° 12/2003 on Environmental Impact Assessments; and Decree of October 17, 2002 on water reuse for irrigation purposes, which defines standards for reusing reclaimed wastewater for crop and landscape irrigation.

7.3 INTRODUCTION OF THE STUDY AREA

The Drâa Valley, located in the southern part of Morocco between the Altas Mountains and the Sahara desert (Figure 19), is characterized by an arid climate. Rainfall decreases from North to the South and from West to East and thus passes from 481 mm/year in Askaouen to 50 mm/year in M'hamid. The city of Ouarzazate receives on average 119 mm/year rainfall (FAO, 2006). The region is characterized by a very high evaporation ranging between 2000 and 3000 mm / year (Tazi, 2008). Further, violent, hot and dry winds accentuate

the process of salt concentration by increasing the evapotranspiration. The Draa valley soils are divided into three classes: a. less evolved soils: 50.8 % of the cultivated surface including 33.1 % of irrigated land, 11.5 % of the young sandy soils and 6.2% from river inflows; b. isohumic soils: 36.2 % of the cultivated surface including 17.9 % of subtropical brown soils, 15.1 % of sierozems and 2.2 % brown young; c. rough mineral soils: 13 % of the cultivated surface. Consequently, despite the scarce rainfall and high evaporation rates, the Valley was recognized for its agricultural richness and fertile soils that nomads used for dates production and exchange with silver and other preciousness products (BioNomaD, 2008) at the Timbuktu market (the most important ancient Western African market). The Drâa basin (as in Figure 20) is divided into the Upper Drâa and the Lower Drâa: the former is part of the Ouarzazate province. The latter is part of the province of Zagora and consists of a chain of 6 oases (Mezguita, Tinzouline, Ternate, Fezouate, Ktaoua and M'hamid, from Ouarzazate towards the desert).

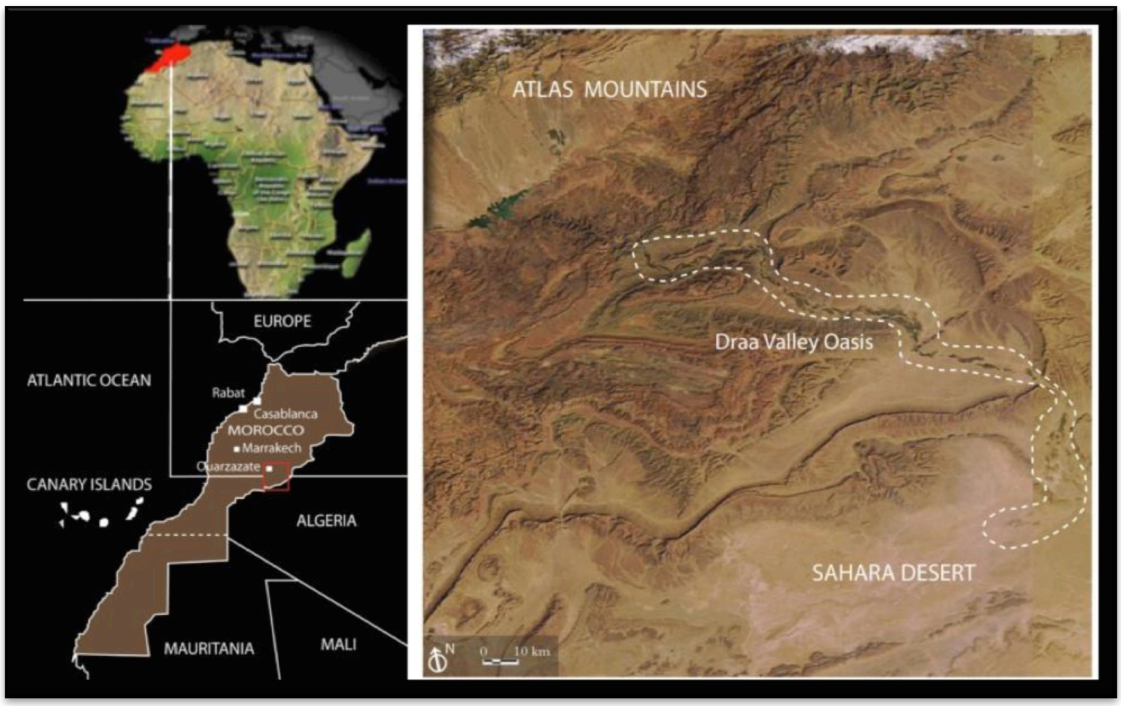

Figure 19: Draa Valley – Case Study area

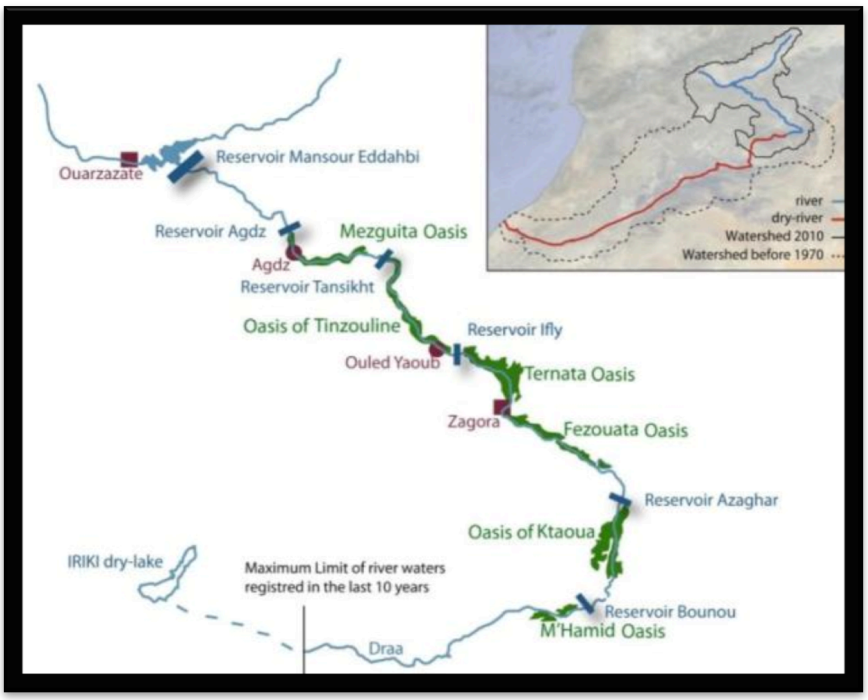

Figure 20: Moroccan Draa Valley and the chain of oases from Atlas Mountain to the Sahara Desert. (adapted from Schulz and Judex, 2007)

7.4 Climate Change and its actual direct and indirect effects

According to the "Projet d'Adaptation aux Changements Climatiques"(PACC project) oases (including the Draa Valley) would experience a reduction from 10 to 40% of the cumulative rainfall during the winter, a decrease in the number of wet and rainy days of around 30% and increasing temperatures from 1 an up to 3.2C° by the year 2050(Morocco, 2011). IPCC confirmed already such trends expecting a decrease of 20-30% in rainfall and a 2.5 to 5C° increasing air temperatures by the year 2080 (IPCC, 2007).

The study carried out by Touchan et al. (2008) analysed the period from 1456 to 2002 underlining an average of 16 drought episodes per century, while in the 1912 to 1992 period an average interval between droughts of only three years was observed (Swearingen, 1992). An ancient Draoua said tells "*saba' shina wa saba' zina*" (seven good and than seven hard) referring to droughts and rainy seasons equilibrium. The resilience of Draoua population relied on their adaptable lifestyle, migrating temporarily during drought crisis. Such strategy changed since the building of a huge dam on the river upstream (see Fig 2,

Ouarzazate water reservoir). Three among the most severe droughts occured between 1980 and 1986 and from 1991 and 1995 (http://www.water.gov.ma).

From 1972 the increasing signs of a deeper regional environmental crisis heve become more evident. Because of droughts (and dam water retention) almost half of the date palm areas among the southern foothills of the High Atlas mountains died, resulting in a reduction from 4575 square km to just 1342 (MADREF, 2001; Ben Mohammadi et al., 2000). Furthermore, as palm trees constitute the core element for the oasis agriculture (and animals fodder crops are usually produced within the palm groves) the number of the animals has also dropped because of both water and fodder unavailability[27] (Heidecke and Roth, 2008; Ait Hamza et al., 2009). Figure 21 illustrates the relationship between precipitations (inflow water into the upstream dam reservoir), outflow waters from the dam and animals fluctuations in numbers and species along the entire Valley. While mules per farmer number remained stable, the majority of the animals were lost, sold, got ill or eaten for auto consumption (Schulz and Judex, 2008).

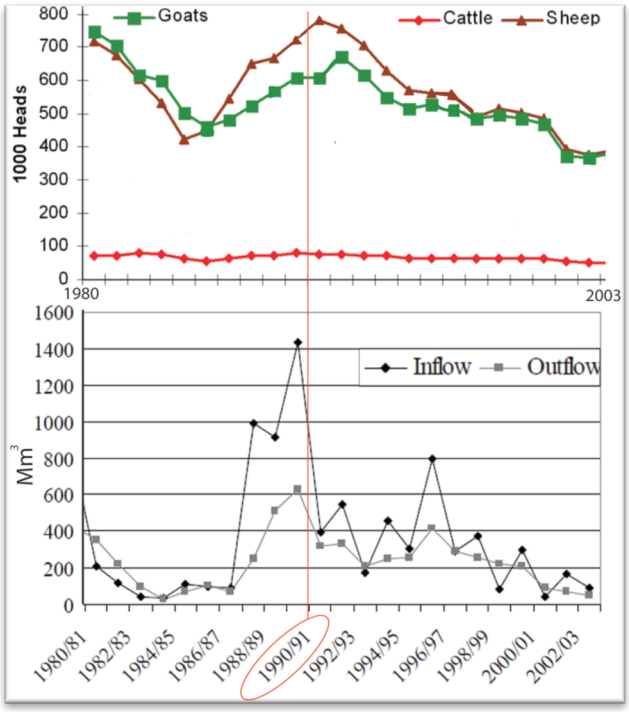

Figure 21: Number of animals in the Drâa region from 1980 to 2003 compared with water flows from Mansour Eddahbi dam (source: Schulz and Judex, 2007)

[27] In the last years (2008-2012) the prices of animal feed were up between 20% and 40%, with a simultaneous fall in prices of livestock between 30% and 50 % (ORMVAO, 2013)

7.5 THE MOROCCAN WATER MANAGEMENT

1. In the past

The arid Moroccan climate has influenced water management all along. Since, the 9th century, when Morocco become an Islamic country rules on property and conflict resolution and ways of managing and realizing collective works for implementing irrigation networks were established. At that time, the institutional frame was drawn on the base of the laws inherited from Islam as interpreted by Moroccan Ulema (Arabic word for jurist that interprets the tenets of Islam in order to complete and explain the rules derived from the Revelation) and by the customs and rules developed in pre-Islamic Morocco. Such system was used as base of the formal and unified legislation introduced by the French Protectorate in 1912 and partially revised since Independence in 1956 (Ouassou et al., 2005). However, it is worth to note that once the Protectorate was established, a very significant change in the water legal system was introduced having a strong influence on the design of all water laws from 1914 onward. According to laws framework issued by the Protectorate, all the surface waters in the country were of public ownership. Moreover, in 1925 a further decree refines the public domain of water and defines the conditions of water use for irrigation and other purposes. In the meanwhile, the protectorate also approves a law concerning water user associations (Associations syndicates agricoles privilégiés (ASAP))[28] to initiate and formalize the development of private irrigation networks. The ASAP is allowed to intervene in the public domain to undertake irrigation infrastructure and was given privileges to implement this work on the infrastructure[29] (Doukkali, 2005). At the time of the protectorate, therefore, three main water rights systems were co-existing: the modern

[28] This law was released in the Official Gazette of August 5th, 1924. The ASAP may be created voluntarily or by the state and can undertake investments to improve land for irrigation, such as construction and maintenance of irrigation networks as well as the equipments used in dry, wet and marshlands. For carrying out these activities, they may receive subsidies and/or water right agreements from the state.

[29] These privileges include the right of passage over private land for canals, expropriation of rights and the rights of access to the infrastructure.

registered rights under the public domain, the ancient customary rights that are recognized and registered and the ancient customary rights that are recognized but not registered. In details, the second subcategory is made of ancient customary rights that are acknowledged by the central administration despite their unregistered nature. Such rights are prevalent in the Souss and Tafilalet regions. In these regions, the customary rights are still binding and their owners do not pay water charges even though the government has constructed a dam and a large-scale irrigation scheme in the area (Doukkali, 2005).

Once obtained the independence, the Moroccan state undertook a very challenging development policy focused on irrigated agriculture. This policy is known as the policy of dams. With the independency, the leading concerns of the new policy was not related anymore to resource protection as in the 1914 and the 1925 laws, but become more oriented towards an efficient use of water for economic purposes; and the state became closely involved in the allocation and management of water resources that were developed at a high cost. As a result, the extent of state intervention in the water sector has increased and the number of dams has increased under the slogan "Building of a dam every year until the year 2000" from 12 in 1960 to 114 by 2006, which has led to a nine-fold increase in water storage capacity (Minoia and Brusarosco, 2006). The construction of a reservoir supplying the Drâa Valley, named Al Mansour Eddahbi, was an attempt to fulfil the social aspirations of the "politique des grands barrages", while concomitantly the creation of the Offices Regionaux de Mise en Valeur Agricole (ORMVA) throughout the country aimed at enhancing the state control in the regional agricultural sector (Ouhajou, 1996). At the same time (1972), in the domain of drinking water, the creation of the Office National de l'Eau Potable (ONEP) was a first step towards acknowledging the need to manage also potable water (Hajji 2006).

2. Water management in the Draa Valley

At the end of the IX century, De Foucauld (1888) described the Dra region as a continuous flow of floodwaters. A century later Jacques-Meunié (1973) notes

that six times between the 1960s and the 1970s the floodwaters of Wadi Dra stretched up to the Atlantic Ocean. A turning point in the history of the watershed was the year 1968 when the work to build the Mansour Ad-Dhabi dam started in Ouarzazate.

Before *the dam: water management at the oases level*

An oasis can be defined as a complex and fragile social-ecological system in which local communities have learnt from centenarian experience how to manage the delicate equilibrium between limited resource availability and environmental pressures (i.e. how to survive avoiding dangerous ecological thresholds) (De Haas, 2001).

The oasis economy is strongly linked with the agricultural sector, which has been formed through centuries of adaptation, so that oases could be considered as anthropogenic agricultural systems (De Haas, 2001). Two main parts constitute an oasis: on one hand, the cultivable part, where mixed farming methods are preferred due to the high water consumption rate of cereal farmers (arabic: fellahs). On the other hand, the part outside the oasis is mainly exploited as rangeland. Inside the oasis, palm trees serve as umbrellas offering a favourable microclimate for the development of other crops. At the same time date palms also represent the first level of a complex irrigation channels hierarchical system that fits (the bigger, called seguías) into other smaller (the secondary irrigation system made of mud channels) channels, creating an intricate network (Figure 22)(Faouzi 1986; Yves and Dolle 1998).

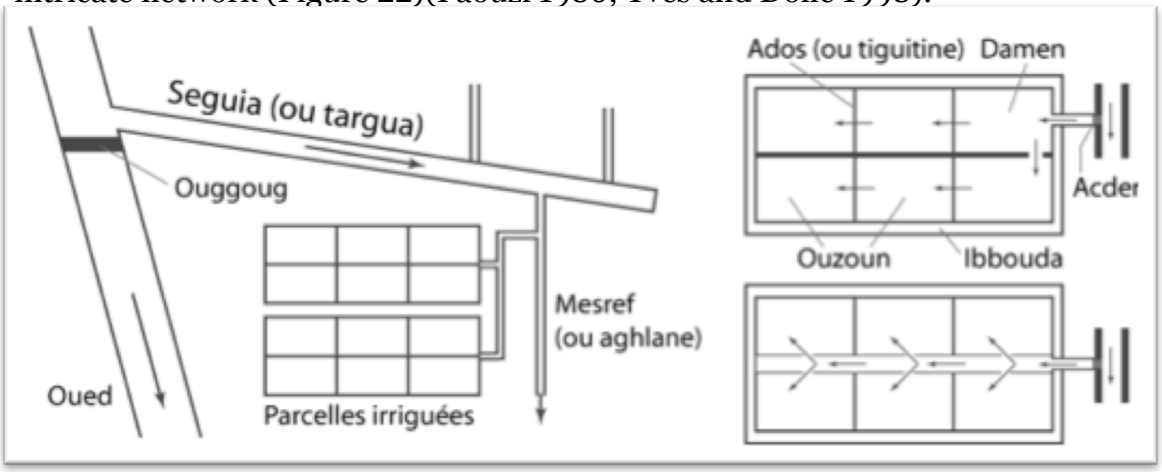

Figure 22: Termes tirés et schémas inspirés de Ouhajou (1996)

From the mud-channels (managed and owned by each village), the community, according to traditional local water property rights, distribute and transport water to all of fields (Ouhajou, 1996; Liebelt, 2003).

The construction of the Mansour Ad-Dhabi dam and its impacts

A decade after the independence of Morocco (1956), the government was planning a series of national energy production projects under the optimistic policy program "grande hydraulique" (ANAFID[30]) which aimed to develop the country. The objective of the Mansour Ad-Dhabi dam was threefold: to produce electricity for Rabat using two turbines; to provide regular water flows for irrigation along the entire valley; and for flood protection for the 19,000 ha of agricultural land (ORMVAO, 1995).

Originally, the reservoir had a volume of 560 million m^3, but this volume decreased rapidly due to sedimentation (Abou-Otmane, 2002). The current volume is estimated to be 439 million m^3 (Bakkoury, 2010), which provides approximately 250 million m^3 of stored water for irrigation and ground water recharge along a total area of approximately 26500 ha. As illustrated in figure 23, each one of the six oases is assigned a shallow groundwater aquifer (Klose et al., 2008) so that the total reserves of groundwater vary between each oasis from the largest (Fezouata, with 127 Ml m^3) to M'hamid (less than 30 Ml of m^3)(Heidecke et al., 2008). Twice a year, a technical committee makes decisions regarding the quantity of water to be released and distributed among the six oases (Faouzi, 1986). Water is first distributed to the Southern oases, and then retained in the five local (dams) reservoirs upstream that direct the water to the oases *seguías*[31] for irrigation (Ouhajou, 1996) (Figure 24, 25, 26). As proposed by the national government, and until the beginning of the severe drought in the Nineties (ORMVAO, 2000), dam construction (therefore a new practice of centralized water management) helped to stabilise the irrigation water supply. Unfortunately, unexpected declines in rainfall and high

[30] Association Nationale des Améliorations Foncières, de l'Irrigation et du Drainage 1990

[31] small canals transporting water from the river to the fields.

evaporation rates seriously threatened the ability of this system to function sustainably during the ‘80s and early ‘90s.

In 1994 the discharged waters were incapable of filling up the shallow groundwater aquifer level of the last oasis (Heidecke, 2006; Klose et al., 2008). After the construction of the dam environmental consequences and measured impacts were tangible. The construction had direct and indirect effects in the water management in the Drâa basin. With reference to direct impacts, interruption of the natural water flow from the river resulted in the drying up of old lakes located downstream (Lake Iriki or Irigui) and consequently the disappearance of biological life; feeding of the downstream water table and soil fertilization were stopped (Ait Hamza et al., 2009); and soil salinity increased in downstream palm groves, which was desalted by the cycle floods discharging large amounts of waters on permeable soils (Zainabi, 2003). The indirect effects are related to the rise of conflicts between the traditional irrigation system based on water rights and the modern system based on the needs of plants; the irrigation technique based on submersion has been introduced without taking into consideration the scarcity of water; and the legal status of lands, waters and trees does not allow any operation of lands regrouping and consequently any modernization of agricultural techniques (Ait Hamza et al., 2009). Such impacts were intensified by droughts, which have seriously affected the region during the recent years. Besides such worrying condition during the last four decades of ‘90s a huge restructuring of the zone has been taking place, pushed also by the Sands war between Morocco and Algeria, which boosts such phenomenon.

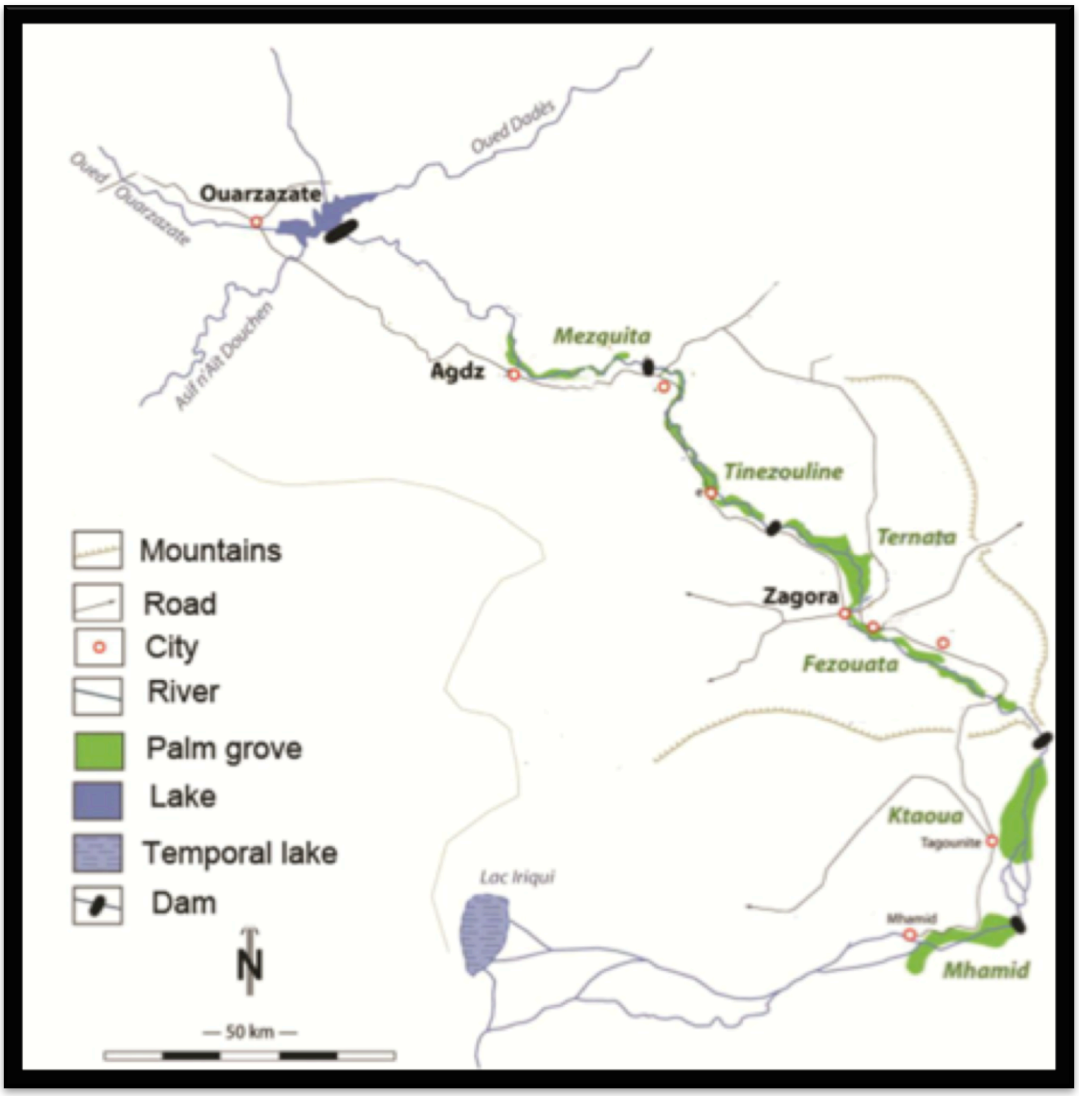

Figure 23: Drâa Valley Oases chain structure (source: Author)

As result of this process, the conquest of new agricultural lands on the edge of traditional oasis can be pointed out. Other effects are related to water pumping as a means of irrigation (Davis, 2006), which is strongly encouraged by the remittances of migrants, to the endless conflicts between old oasis settlers and old nomads compelled to settle down, and last but not the least, to the urbanization of the oases. Consequently, water stress can be linked mainly to three reasons: (a) rapid population growth and changing habits of the population; (b) tourism development and; (c) extension agriculture outside the traditional palm.

Figure 24: Irrigation system in the Draa Valley (source : Author)

Figure 25: the Mansour Ad-Dhabi dam

Figure 26: one of the distribution water channels (at the bottom)

In 1995, a new legislation was voted by the Parliament and adopted by the Government. This 1995 law called "Loi sur l'Eau – Water Law" (B.O. 4325/1995) constitutes the main water legal frame. This decree has recognized that all water resources are a public good and has instituted river basin agencies (RBA). In general, the purposes of the law are: (1) to rationalize water use, providing access for all to this resource and reduce disparities between cities and villages, ensuring water security all over the country; (2) to improve the development and use of agricultural water, and 3) to enhance the security against illegal water resources development and water pollution activities. In detail, the creation of river basin agencies should have opened the floor for a more decentralized and participatory water management programme. The River Basin Agencies are in charge of managing and regulating water resources besides their role in developing and supplying water. They have to monitor and regulate water use and water quality as well as plan and organize flood control and water-related emergencies within their respective basins' (Doukkali, 2005). According to the new regulation (Law 10/95), Morocco is divided into 9 major river basins, with long-term water resources development policies planned and specified in Integrated Water Master Plans. The RBA Water Master Plan, as specified in Article 16 of the water law, is a constituent part of the National Water Master Plan. It can be reviewed and amended every five years if changing conditions warrant amendments even though it must be formally approved by decree every time. Establishing these plans mainly aims to estimate water demand from different sectors such as potable and industrial water, irrigation and hydropower generation, and to determine optimal integrated scheme of the water resources development. In the meanwhile, the government of Morocco decided to significantly reorganise its water administration and to promote the private sector ("gestion déléguéé" - private-public partnership) in water resource development and management. First, the concessions for water distribution in four large cities (Tangier, Casablanca, Rabat and Tetouan) were granted to private water companies, and the private sector involvement was also

extended to the irrigation sector in 2002[32], encouraged by an enthusiastic World Bank (Simon, 2011; Houdret, 2012). The project was the first of its kind in Morocco or anywhere in the world (IFC, 2004), since the private sector is responsible for mobilising and distributing water, including the building, financing and management of the infrastructure

7.7 ACTORS INVOLVED IN THE WATER MANAGEMENT

The institutional organization in Morocco is based on 3 levels (national, regional, and local), including the major stakeholders involved in the water domain. However, the current institutional setting does not clearly state the goal of intervention of each ministerial department. However, it addresses the issue of coordination through both the consultative institutions at the national, regional river basin and local levels and the executive central administration authorities. The Moroccan model for water management in terms of decision-making, coordination and implementation at the national, regional and local levels involves advisory bodies and the executive authorities at the different levels (Figure 27).

[32] In 2002 two projects began: the construction of a transmission pipeline (Guerdane project) and a distribution network (the Gharb project).

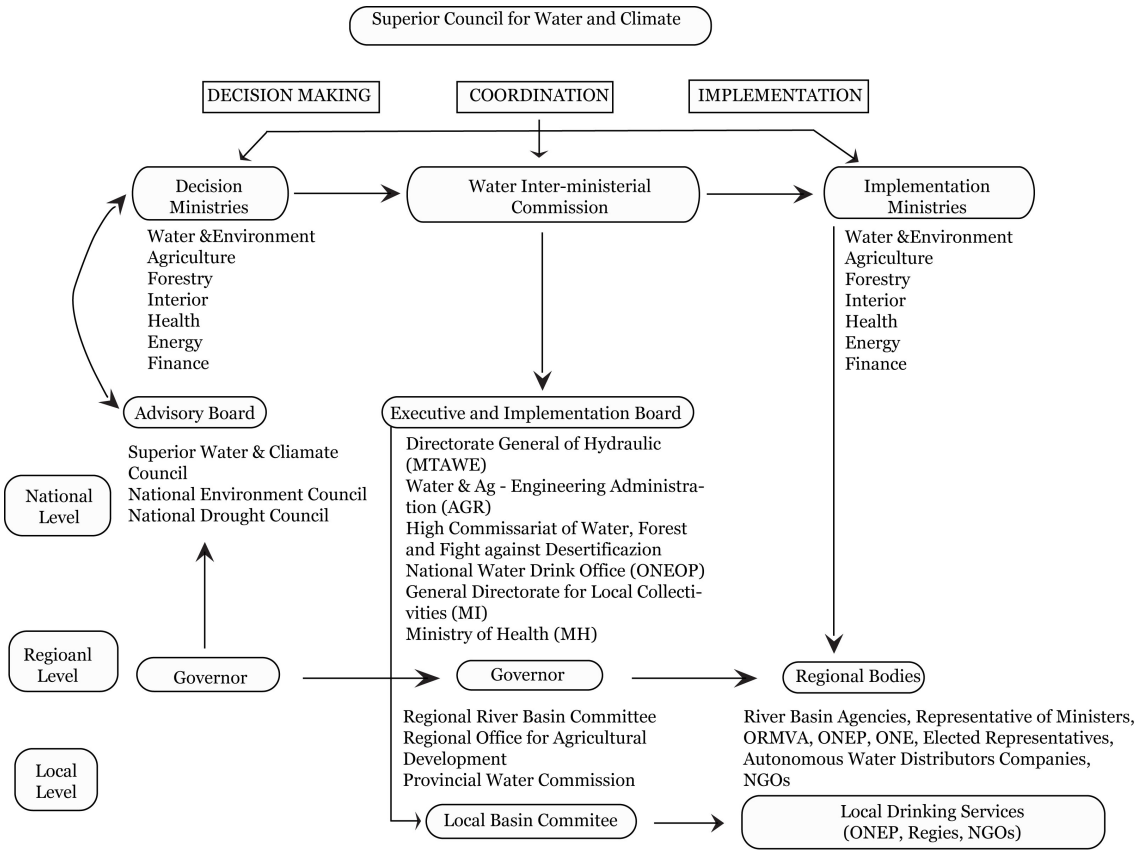

Figure 27: Water resources management in Morocco (Ouazzou et al., 2005)

National Actors

The Ministry of Territory Planning, Water and the Environment (Ministère de l'Aménagement du Territoire, de l'Eau et de l'Environnement-MATEE) is the central authority responsible for the implementation of water policies and for all issues relating to water exploitation, conservation and use. The MATEE includes two entities that are involved in water management:

- *The Secretariat of State in charge of Water and the Environment (Secrétariat d'Etat chargé de l'Eau et de l'Environnement- SEEE).*

  The SEEE who acts as the intermediary between the central government and Hydraulic Basin Agencies. Its tasks include: water resource

assessment, monitoring, transfer, management, security, capacity building, and research and development. It also monitors meteorological events and evaluates past and future climate trends.

- *The National Office for Drinking Water (Office National de l'Eau Potable-ONEP)*

  The ONEP was created in 1972 and it is responsible for the planning and operation of infrastructure for drinking water production, for monitoring and controlling water quality of drinking water supply sources, for potable water distribution and sewage collection and treatment. The ONEP it is responsible for approximately 80% of the total water supply and 25% of the distributed volumes.

High Council for Water and Climate (Conseil Supérieur de l'Eau et du Climat)

High Council for Water and Climate was established in 1987 with the aim to formulate the national water and climate policy and assess the national strategies related to these subjects. Additionally, it revises the national water plan and the integrated water management plans.

Ministry for Agriculture and Fishing (*Ministère de l'Agriculture et de la Pêche Maritime*)**.**

This Ministry is in charge of developing and implementing Government policy in agricultural production and rural development. It plays also a major role in water resource management, since 87% of the nation's water resources are allocated to irrigation. The Ministry of Agriculture is responsible for irrigation policy, on which it coordinates with the SEE.

High Commissariat for Water and Forests and Fight against Desertification (Haut Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification).

This High Commissariat is in charge of natural environment, forestry, wetlands, fresh water bodies, reforestation, preventing desertification, and conservation of natural ecosystems.

At national level other entities and ministries, involved directly or indirectly in water policy formulation and water management operations are:

- *National Electricity Office (Office National de l'Electricité- ONE)*, as water used for hydroelectricity production is afterwards diverted for irrigation purposes.
- *Industry Department (Direction de la Industrie under the Ministere de la Industrie, Commerce et des Nouvelles Technologies)* as industrial water requirements are usually supplied through the ONEP infrastructure.
- *Ministry for Domestic Affairs (Ministère de l'Intérieur)* responsible for the support of local associations, through the DGRSC and the DEA.
- *Legislatives bodies (Instances législatives)*. The legislative bodies of Morocco are responsible for passing laws and therefore they are involved in formulating and passing pieces of legislation related to water resources.
- *Ministry of Finance (Ministère de l'Economie et des Finances)* for the financial monitoring of water projects and the financial management of services provided.
- *The Ministry of Economic Affairs*, which intervenes in the definition of water tariffs.

Consultative institutions and bodies

The consultative institutions in charge of advising the various line agencies and ministries do not have regulatory powers. They issue recommendations and approve plans. These institutions are the following.

The Superior Council for Water and Climate

The main consultative body, the SCWC includes all administrations involved in the water sector, representatives of the parliament, representation of users and nominated experts that have competencies on the water issues. The SCWC convenes to address issues of national importance and formulate recommendations on the options of planning, mobilization and management of water resources.

The National Council for Environment (Conseil National de l'Environnement, CNE)

The National Council for Environment was created in 1981 but has been reactivated only in 1995 in order to advise the government on all environmental issues. The main task is to orient and adopt the National Environment Plan. On water issues, the NCE contributes to define guidelines that limit conflicts between institutions and promote environmental awareness and education.

The Permanent Interministerial Council for Rural Development (Conseil Interministérial Permanent du Développement Rural - PICRD)

The Permanent Interministerial Council for Rural Development was created in 1999 following the severe drought episodes in Morocco. The Prime Minister heads this Council and the MARD is responsible for its technical secretariat. The main activities of the Council relate to the declaration of drought onset, the preparation of the National Drought Plan, the supervision of the planned

drought actions and the elaboration of rural development strategies for Morocco.

The National Drought Observatory (Observatoire national de sécheresse – NDO)

The National Drought Observatory was created in 2001 as an entity attached to the General Secretary of MARD and based at the Institut Agronomique et Vétérinaire Hassan II (IAV), as a result of a ministerial decision to locate it physically in an academic institution allowing multidisciplinary collaboration, and giving it certain neutrality with regard to policy pressures. It has an organizational structure involving regional centers in research institutions in Settat, Meknès and Salé, and a framework of working groups that can include and be led by a number of partner institutions. The main mission of the Observatory is to provide decision makers with decision support tools for drought management and to advise on strategic drought planning, preparedness, mitigation and response.

Regional

Regional Agricultural Development Authority (Offices Régionaux de Mise en Valeur Agricole, ORMVA)

The ORMVAs are autonomous bodies that operates under the umbrella of the Ministry of Agriculture were first established in the 1960s with the aim of decentralizing irrigation water management. At present, the 9 ORMVAs are in charge of managing and promoting irrigation waters activities at the irrigation district level. Their mission includes: assess agricultural development schemes in irrigated perimeters, within the framework of the large hydraulic infrastructure management; management of the irrigation districts; exploitation and the maintenance of irrigation equipment at the irrigation district level; providing technical assistance to farmers; and collection of irrigation water fees.

River Basin Agencies (*Agences du Bassin Hydraulique*, ABH).

The ABHs were created by the Water Law (Law 10-95) and one ABH was established for each of the nine main river catchments in the country. The ABHs are public organisms that benefit from legal personality and financial autonomy, and are in charge of water resources management in the basin. Their role includes implementation of water management plans, enforcement of water rights, financial and technological assistance to private operators, water monitoring, studies, water resources protection, and flood control. Each ABH operates under the supervision of a board that sets its general policy and approves its action plan. The Board is composed of one-third government representatives, one-fourth public organizations and the remainder of representatives of corporate chambers, regional and local councils, ethnic collectivities and water user associations.

Local Actors

At the local level there are four institutions which are accountable to their regional counterparts: the local offices of the ONEP (mostly in urban settlements), the Development Centers (Centres de Mise en Valeur - CMV) and the Centers of Agricultural Development (Centre de développement agricole - CDA), which are front-line institutions under the ORMVA for providing agricultural extension support to various development activities. of the ORMVAs for agricultural matters, and the Service Eau, which works essentially in rural settlements. Furthermore, there are the Agricultural Water User Associations (Association d'Usagers de l'Eau Agricole - AUEA) which are associations formed by villagers managing a tap water system installed through the water supply programme PAGER[33].

[33] The programme for the Distribution of Drinking Water to Rural Populations ("Programme d'approvisionnement groupé en eau potable des populations rurales initiated in 1995. (http://www.onep.ma/)

Agricultural Water User Associations (Association d'Usagers de l'Eau Agricole - AUEA).

Though AUEAs were established shortly after independence, they wielded very little power until the 1990's when a government decree gave them more power over local water distribution (Bennis and Saeq 1998). Their current role is to oversee service levels, charges, and water allocation (World Bank 2007a in USAID, 2010). Each member pays dues to cover the expenses of their AUEA, which also results in more personal involvement in the water sector and more incentive to maintain the system (Meinzen-Dick 2000). The AUEAs in Morocco also give farmers some influence in national irrigation policies (Tsur et al. 2004). An association for irrigation water users can be created on the demand of two-third of the farmers in an irrigation district. They aim to help farmers in implementing irrigation and drainage programs and in managing irrigation infrastructures. AUEA sits in the board meetings of ABH and contribute therefore in formulating water policy at the basin level.

7.8 The new (?) Moroccan water management in the Draa valley

Nowadays the Draa river belongs to the 10 most arid catchments of the world (Ravena et al., 1998) and it one of 25% of the world's rivers that run dry before its estuary (Molden et al., 2007). Within this context, the River Basin Agency has been established by the decree 2-00-480 according to the law 1995 "Loi sur l'Eau" (Water Law) in 2000. Despite more than nine years have passed since the creation of this institutional structure, the river basin master plan designed by the River Basin Agency of Souss-Massa-Draa has not been approved yet (year 2012) evidencing thus the difficulties of implementation of this integrated water resources management framework (Jeffrey and Gearey, 2006; Lankford and Cour, 2005; Biwas, 2004). Moreover, in contrast with the water law's goal of decentralized water management, the Moroccan Government has already planned the construction of a new dam, called Tiouine, upstream Ouarzazate (see Figure 28). It is currently under construction (it will be completed by 2014) and will store up to 273 Mm3 water (according to the head of the Souss-Massa-

Draa River Basin Agency interview) or 100 Mm3 of water (according to Monje et al, 2011; Martin Bravo and Salgado Ybern, 2008). Such water will be used to serve in combinantion with the old damthe increasing urban demand of drinkable water of Ouarzazate and because of the decreasing water quality from the old Mansour Al-Dhabi dam, suffering high sedimentation rates. Most interviewed people declared that building another dam in this area will not be a long term solution due to the local high sediment accumulation and high evaporation rates (interviews, 2012). At the same time, as consequence of decentralization Water Users Agricultural Associations (AUEA), that are the official structures responsible for water management at the Municipality and village levels (Maroc, 2009), are enganging in various local projects, such as water saving training courses, a desalinization plant in Tagonite and a sewerage project in Zagora. These projects are showing an increased capacity of the still weak water management skills of such new decentralized local organizations (BTC and ONEP, 2009).

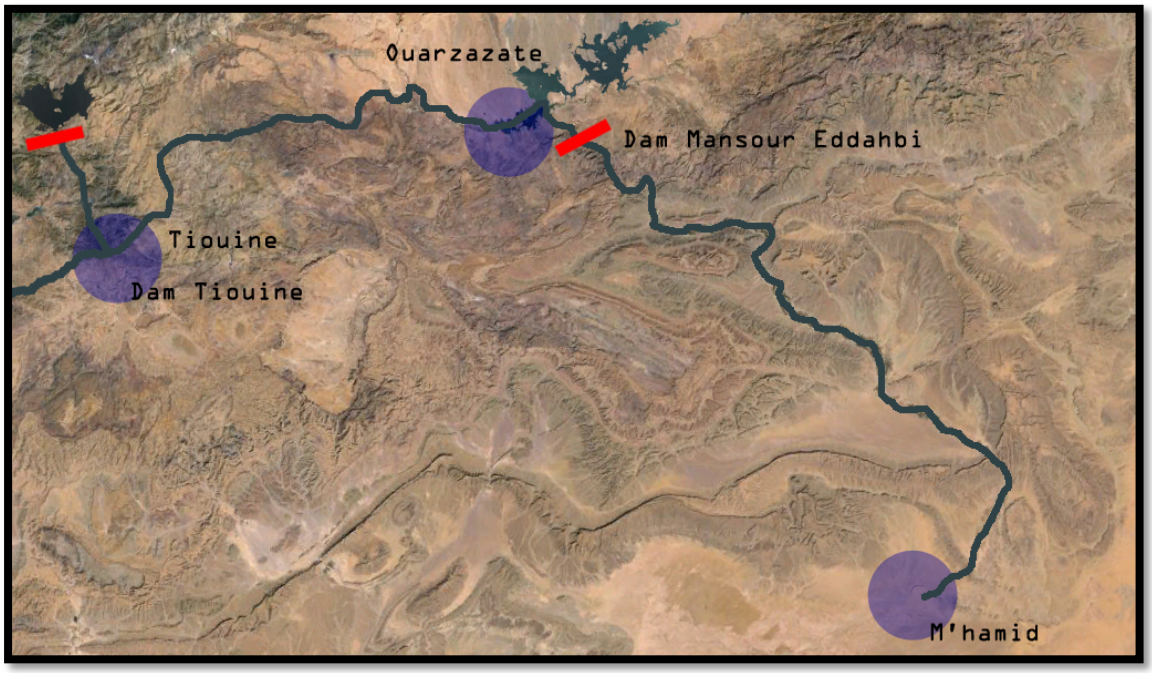

Figure 28: Tiouine (under construction) and Mansour Eddahbi (existing from 1972) dams (source: Author).

From interviews, though not confirmed from any official report yet, drop-to-drop technique extensive program would be implemented along the oases valley. All those new measures oriented to a more efficient water usages together with the process of decentralization have to deal with the integration

(or coexistence) with many autonomous adaptation to droughts generated as reaction to the construction of the dam up to now. These responses, illustrated in the next section, are characterized, in some cases, by a low level of sustainability and underline a decline in the level of trust and legitimacy of the governmental organization by those living in the Draa Valley. Therefore, the implementation of such new measures as well as of a new water management approach will not be an easy task since first of all it will be necessary to re-establish trust-based relationships.

7.9 Autonomous short terms adaptations to droughts and their cross scales effects.

1. In the past

In the oases a strong collective and hierarchic cooperation in the local management permits to cope with scarce resource availability and recurrent droughts (Beaumont, 1989). Their strategies are surviving thanks to a complex and strong social capital, accumulated from ancient knowledge regarding the cultivation of dates palms (Clouet, Yves and Vincent Dolle, 1998) or herd movements of nomads (Aarib) (Davis, 2005; Idriss, 1991). In fact, different adaptive strategies have been taken both by nomads and farmers to face the lack of water and the difficult environment. The flexibility (and persistence) of nomads is successful in managing periodical change to the non-exclusivity of rights of admission upon lands, allowing them to access new grazing areas or migrate temporally. Temporal migrations, represented a key strategy both for nomads, who kept their status by becoming temporary soldiers, and for farmers, who remained out (thanks to job opportunities in cities) of droughty areas and are used to come back farming once the first rains start again. In sum, resilience in dryland was deeply influenced by a constantly flexible and adaptive lifestyle condition, in which social capital and temporal migrations played an essential role in maintaining those communities, their identity, structures and functions.
Following this rhythm of periodical migrations in order to keep the oasis social-ecological systems in a sustainable (although precarious) equilibrium, cities as

well were experiencing periodical fluctuation in population size. Urban areas have always represented a key point along the territory both for nomads and farmers. At the same time urban form, structure and functioning were strictly related to the ecological thresholds of the surrounding environment. Consequently, and in general terms, oasis carrying capacities have been never exceeded and the availability of freshwater never pushed beyond the watershed recharge potential. This is also explained by the fact that date palms (and so the oasis ecosystem) represented the key essential element for those societies, providing microclimate and soil for agriculture (and survival from the desert) and wellbeing thanks to the dates palm commerce. As the human pressure was always below environmental resource availability, the stresses that these social-ecological systems could experience mainly depended upon external drivers (such as sandstorms or temporal droughts) and recovering have always occurred without the need of societal transitions (relying on the natural and climatic cycles and seasons happening). The local dependency on resources has prevented substantial sprawl. The flexible lifestyle practices in the valley illustrate the importance of social capital in managing and coping with cyclic water-stresses.

2. *Present situation*

Because water for irrigation is not released from upstream dam continuously[34], and the water distribution between the six oases begins downstream (in contrast to the general rule that water is used upstream first) (Faouzi, 1986), even upstream oases are highly affected by the severe droughts (Outabhit, 1992).

In turn, periodical locust invasions and the constant wind erosion that is the mayor driver of soil silting (silting covers nowadays 30.000 hectares just in the

[34] The amount of released water, to be divided between the six oasis reservoirs, is discussed in a yearly meeting between different local institutions, however there is no clear rule as to how this water is distributed. However, the six annual discharges of the dam in 1973 (the minimum for a satisfying the Valley agricultural cycle) diminished to 4 and until its ecologically unsustainable minimum released during 2002–3 (2 times less water than the 40milion of m3 necessary to recover the groundwater system).

provinces of Ouarzazate and Zagora) (Maroc, 2001) worsen the oasis state. Furthermore, erosion results along the Drâa to be to an average of 5.8 m3/ha/year (Ben Mohammadi, 2000). Erosion is provoked by land-uses and water management unsustainable practices, as the cultivation for exploitation of sandy soils (Ben Mohammadi, 2000), uncontrolled firewood collection and others (Mainguet, 1979), contribute to the increase of soil vulnerability and the desertification process. Moreover, other environmental stressors have exacerbated the social-ecological crisis, such as the Bayoud Fungus epidemic, a palm tree illness caused by drought and which appeared in the '80s destroying more than 2/3 of palm trees in Morocco (thus in most oases more than half of the commercial date palm trees have been destroyed, with consequent losses of income sources, foreign currency, reduced extension of annual crops protected by the palm trees and finally increased speed of soil desertification). Thus, once the oasis life styles and the traditional land management practices have broken down due to the environmental crisis (Davis, 2005; Platt, 2008), a strong urbanization process took place. Consequently the social autonomous adaptations (of individuals and farmers) drastically changed from the previous temporal migration practices, responding to the new shocks with unsustainable short-term strategies such as abandoning land or using an increasing and uncontrolled number of motor pumps for groundwater extraction, encouraged by the government that could get high fees introduced by the the 1995 water law for the permission to drill[35].

This individuals reactive capacity provoked an unsustainable chain effect and the number of water pumps has grown from 2.000 in 1977, to 4.000 in 1985 (Faouzi 1986), nearly 7.000 in 2005 (Ait Hamza et al., 2009) and more than 10.000 in 2011 (interviews, 2011-2012). Last oases were obviously the first to suffer such upstream groundwater uncontrolled extraction causing their groundwater and soils salinization (Casciarri, 2003). Although the salinity of groundwater is naturally high due to the geological characteristics of the region

[35] Boukhima (2009) explaines that the unrealistic financial conditions set by the l the 1995 water law (payment of high fees to get the permission to drill a well, notably) had led to all sorts of illegal, de-regulated and ecologically destructive digging of wells by Syrian enterprises in the area of Souss-Massa-Darâa where the annual water deficit had already reached 233 million cubic meters.

(ORMVAO, 2000), salt concentrations were increasing because of the high evaporation rate and the increasing extraction of groundwater for irrigation (Ouhajou, 1996). These represented a potential individual crisis solution offering crops that were economically more profitable for the farmers owning the deeper wells (because high water consuming). For example, after the Bayoud[36] disease, the oasis space dedicated to dates production decreased by 34% (ANDZOA, 2013) and watermelon crop market has emerged as a very profitable solution. Without any ecological concern regarding the large water volume required, watermelons fields increased from just 150 ha to more than 2000 just in the last 2 years (Table 15, ORMVAO, 2013).

	2010	2011	2012	2013
Watermellon farming area (ha)	150	450	670	1130
Watermellon Production (quintals)	77650	240000	ND	ND

Table 15: Watermelons production in the province of Zagora (Source: ORMVAO, 2013)

To conclude, the shift between the earlier sustainable social-ecological equilibrium to the ecologically unsustainable centralized water management has brought a wave of different, unplanned and unexpected functional, structural and behavioral dynamics. At first glance we can see that from a more resilient condition, resilience expressed as adaptive capacity of farmers, the management from an awareness of the valley's ecological thresholds, its functioning and equilibrium (thanks to social capital and behaviors), to short-term, unsustainable activities such as ground water extraction using motor pumps. At the same time, migration radically changed in its function from a temporal and flexible strategy to a permanent people state, as emigrants, due to the failure of groundwater extraction and competition among farmers and between oases.

[36] A disease of date palms, caused by the fungus Fusarium oxysporum f. sp. albedinis (Foa) (El Modafar, 2010)

Nowadays neither the old irrigation system, nor modern motor-pumps, can satisfy the Southern farmers dramatic water needs, caused by the uncontrolled (wells proliferation) and not integrated water uses along the Valley (Rademacher, 2008).

7.10 THE URBAN PHENOMENA

Oasis economy usually strictly depends on essential ecosystem services that consequently determine the size and spatial configuration of each settlement (each Kasbah). Like a medieval settlement, it seems that oasis Kasbahs have always had the same functions as medieval walled cities: dependent on the local natural environment, limited in growth and defending the citizen from the potentially hostile outside environment. Indeed, till the beginning of the XX century, the current capital city of the region, Ouarzazate was just a Kasbah, positioned as a crossroads for strategic territorial routes as illustrated in Figure 18 (from Marrakech to the south, and from Agadir, the principal southern coastal city, to the east).

Since 1912, Ouarzazate was converted into a garrison town and only after the 80's did the urban growth phenomenon take place due to the new independent Moroccan Government developing plans (including the Mansour Eddabi dam construction) and the envisaged mass tourism thanks to the new vocation as a filmmaking location. Thus, between 1994 and 2004, with an annual population growth of 3.3 %, the city reached 74,600 inhabitants. As mentioned before, the urbanization process was a direct result of the environmental crisis that lead to land abandonment and migration of entire families to urban areas (Figure 29). Furthermore, thanks to the policy of decentralization advocated by the state since 1976, the reinforcement of the role of communal districts was improved. As a result, urban centers have developed faster than the rural areas (0.8 % average annual growth) and the four urban areas of Ouarzazate, Tabount, Zagora (considered previously as part of Ouarzazate become an independent province in 1997) and nowadays Tinerhir host 77.6 % of the urban population of the entire valley (Zainabi 2003). At the same time, due to unsustainable autonomous adaptations to droughts (uncontrolled pumping of freshwater from

groundwater reservoirs) the ancient structure of common resources management collapsed within the oases previously stable socio-ecological equilibrium. Almost 40 years after those first waves of changes (centralized water management, tourism market increasing dependency and urban phenomenon) another element has been introduced to enhance urban processes: the development of a new strategy to boost the share of renewable energies to satisfy the increasing domestic demand and to avoid the dependence on imported energy (almost 70% nowadays, from O.N.E.).

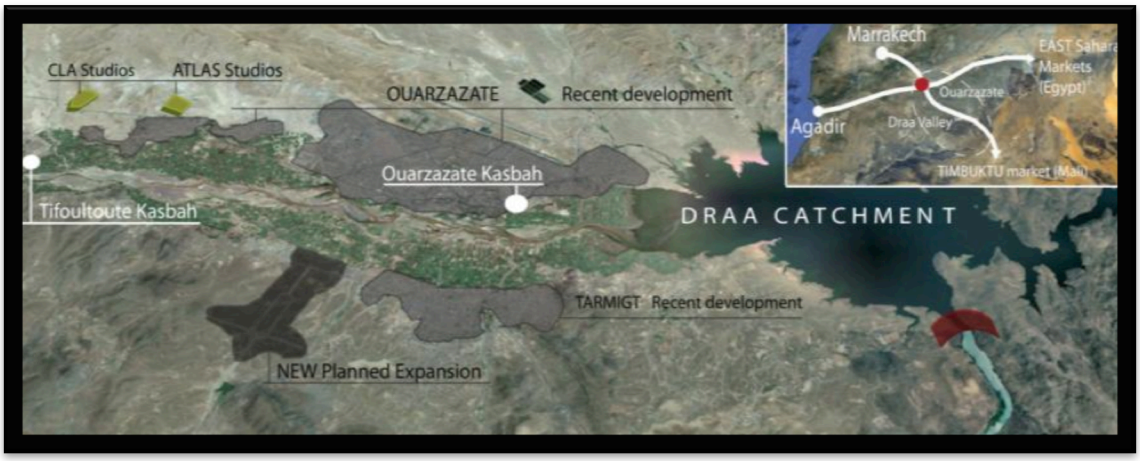

Figure 29: Ouarzazate present urban assessment (source: Author).

This was a necessary step to guarantee energy independence from external resources.

7.11 Renewable energy, water consumption and increasing desertification

In 2010 the King introduced the new Moroccan Renewable Energy Plan in Rabat wishing to install five solar power plants before 2020, with a total capacity of 2000 Megawatts (Mw) and a cost around Euro 7 billions (Konate et al., 2012). These plants can meet the CC mitigation policy aims, reducing Moroccan energy importation dependency and supporting the growing demand for electricity supply also for other Middle East (Emirates) and North Africa (MENA) countries. In fact, this national renewable energy project is connected to a bigger long-term international cooperation project, called DESERTEC and in which takes part Europe (Germany) and the MENA region. The final aim of

this macro project was to produce clean energy (in a centralized way) from the desert potential sun power (Bakkoury, 2010) and desalinated water in order to respond to the 2/3 of the entire MENA region energy demand. Finally another 15% of energy was planned to be sold and transported to Europe by Direct Current High Voltage (which would just loss a low 10-15% of energy during transmission) (DESERTEC, 2011). The first solar power plant, of 500 Mw, was planned over an area of 2.500 ha just 10 km from Ouarzazate. Since 2010, because of recent financial problems, a solar thermal parabolic plant is under construction with a capacity of just 160 Mw3 instead of the planned 500 Mw (BMU, 2011). Such solar power plan should cost around 1042,32 Ml Euros (Konate et al., 2012). Furthermore, according to interviews and official reports, it should be capable to open new local markets, as just in Ouarzazate province rural households represent around 300,000 people with an energy consumption of about 140 MW (Maroc, 2008a), which is currently satisfied through firewood (in that way the project should also helping in reduce human pressures on vegetation).

Despite the CC mitigation principle behind this project, the potential sustainability by the concept of renewable energy production and the replacement of firewood with solar energy, we still see some critical points regarding the social resilience and ecological regional future related to such option. In fact, due to the (again) centralized structure of the solar energy production system, people would be totally dependent from the energy (as market and tariffs) provided from the plant owner. In such way resilience in term of citizen increasing skills and redundant options for surviving in case of crisis is not enhanced, as they would have no control over the energy production. Furthermore, centralized systems are less resilient than the decentralized or distributed ones if some natural hazard (or accident) happens (Baran, 1964). At the same time, from the resilience to environmental sustainability lens, this centralized plant will have a high cost in terms of water withdraw from the Drâa Ouarzazate water reservoir (due to its “humid” cooling system). This amount varies according to the different sources, from around 2 Mm3/year of freshwater (Project official report, Konate et al., 2012) or around 5 Mm3/year (according to the Drâa Water Basin Authority interviews).

Considering the actual environmental crisis in the southern oases, climate change predictions (section 7.4) and from the numerous interviews outputs, we believe that linking (after creating) new consumers (previous firewood energy supply poorer people) to a centralized, high water requiring, solar plant it is not the most resilient, neither sustainable, option to fix CC issues. In fact, it would finally enhance the Southern oases desertification process because of its added water consumption upstream. Furthermore, looking at numbers, the average price for such solar power energy production stands around the 22 cents (Euros) per Kw, while Moroccan actual subsidized price for energy is just equivalent to 4 cents/Kw (Stern journal, n.31; 07-2012) and photovoltaic energy production would cost just 20 cents/Kw. So, actually, photovoltaic choice would be the cheaper, more resilient (because is a distributive network, people has de control of its own produced energy) and sustainable (because of water use). Furthermore, its implementation could be gradual and not imply huge inversions from the first moment.

7.12 New directions in saving valley agriculture

Lunched in 2008,the new national agriculture program, the plan “Maroc Vert” (Green Morocco) aims to develop a more independent country from cereal imports and to abate the exodus of people from rural areas (Maroc, 2008a; Lybbert et al., 2009). It values the importance of the agricultural sector for the country and places its modernisation high on the national and international agendas (ADA, 2009). Its goal is to support the sector in two ways: by developing large-scale agriculture with high value-added production (Badraoui et al., 2000; Davis, 2006) fostering production techniques, extension of cropland, improvement of localized irrigation techniques and an improved processing of agricultural products (Maroc, 2008a) and by assisting vulnerable actors and combating rural poverty through the improvement of small-farm incomes. However, the plan has been firmly criticised. A foreign consultancy was commissioned to draw up the plan, and it has not been published in its entirety or publicly discussed, or endorsed by independent experts (Houdret, 2012). One of the key criticisms is that the €50 million to be invested between

2008 and 2018 is mainly allocated for the 'First Pillar' of the project and favours large-scale agriculture at the expense of the majority of Moroccan farmers cultivating small plots of land. The plan also states that agricultural incomes are excluded from paying taxes until 2013, which mostly benefits large investors. Privileging the 'First Pillar' is also likely to make the country even more dependent on import of staple foods (Akesbi, 2011) in addition to be in clear contrast with the declared goals of the plan. Besides this, the proposed leasing of more land to private investors may also have adverse effects on pastoralism, rangeland and livestock production and further destabilise the vulnerable nomadic population. Furthermore, from the majority of the interviews emerged that the orientation toward a cereals and export oriented agriculture is harmful for the long run resilience (higher risk of crop failure and foreign markets fluctuations dependency) and sustainability, because of its extremely high water consumption rates (interviews, 2010-2012). On the other side (date palm conservation for more resilient and sustainable oases) a date palm planting program of five years with a budget of 26,431 Ml USD[37] (to cover a total area of 16,000 hectares and 9,248 farmer beneficiaries) has started in 2009. The project aims to improve the state of the date palm culture, which has been dramatically affected by droughts, floods, desertification rates and soils siltation, as well as from the Bayoud (lethal mushroom) disease. Furthermore, it aims at upgrading the irrigation system over a length of 50 km to foster date palm cultivation by the introduction of 420 Plans vitro-resistant disease Bayoud, to clean tufts to 155,000 palm trees, promote small scale irrigated agriculture and to train farmers in terms of productivity and product enhancement with reference to such production system. In addition, the coexistence of watermelon crop, new cereals foreign markets and date palm trees planting for oases microclimate should solve water regional flows uses conflicts in integrated way, otherwise one program could mean the other failure.

[37] It is funded through a partnership between the Ministry of Agriculture, the Hassan II Fund for Economic and Social Development and the MCA (Millenium Challenge Account).

In the meanwhile drought events were impacting negatively vegetation, wildlife and the agricultural sector, desert tourism was growing fast (Ait Hamza et al., 2009) thanks to foreign visitors attracted by Ouarzazate boost of American cinema industry (Hollywood), who has invested in the city building one of the largest movie studios of Africa. Becoming a famous filmmaking location Ouarzazate started growing during the last decades with an annual population growth of 3.3 % between 1994 and 2004 (Schulz and Judex, 2007) and with a political wish of reaching (from just the 4524 beds in 1998) the 20.000 beds before 201038. Zagora, as southern and second mayor city, also started to benefit from tourists arrival, as M'hamid (the last oasis) found in tourism potential business and survival opportunities after the most severe droughts. Furthermore, as from Sand War Algerian-Morocco borders were closed to nomads, increasing number of settled people started to find new sources of income from tourists working as desert guides (interviews, 2010-2012). However, notwithstanding tourism sector was becoming a solution to environmental crisis, the water consumption for tourist porpoises rose contributing to Southern oases water scarcity and groundwater (and soil) salinization (Casciarri, 2003), as the majority of water comes from upstream extraction (interviews, 2011). The ambitious project in the '90s, from European Lions Clubs, to build the "Royal Golf" and "El Ahbab" five stars hotels in Ouarzazate, taking advantage of the Mansour Al-Dhabi reservoir freshwater, constitute the living example (within the watermelons crop sprawl) of the non-integrated nor responsible regional water management. Looking at the Drinkable Water Office database Ouarzazate hotels reached alone the 40% of total urban water consumption (ONEP, 2010).

As far as the highest star rating hotels are the ones that show more water consumption, is it also true that they are at the same time the only ones that could build the more sustainable options of incorporating water saving principles (storage, filtering and re-use strategies) once they become conscious of water scarcity. In fact, after Royal Golf failure (in few years too salty level

[38] Due to the global financial markets crisis from 2008 those numbers remains just wishes, and in 2010 the total bed numbers in Ouarzazate was stimated in 7.685 (Ministère du Tourisme et de l'Artesanat, 2010)

waters from the dam reservoir used for irrigation transformed a green golf field into an arid dead environment) many structures, mainly in southern oasis, start to incorporate saving water principles in their hotels. One example is the filtering and reusing for agriculture of the water from the swimming pools during dryer seasons (Interviews, 2012). As from a driver to an opportunity, evidences during the last years of interviews and fieldwork in Southern oasis, have demonstrated how tourism (incomes) and social networks constitutes essential tools for coping practically with environmental crisis and desertification. Thanks to sharing knowledge and using correctly social networks as a tool to make aware foreign tourists about desertification, some local Bedouin camps in M'hamid (see Figure 30) start self-building sustainable water storage-filtering and reuse infrastructure in their camp in order to demonstrate that it is possible to manage in a sustainable way water for tourism and farming also in the middle of the desert.

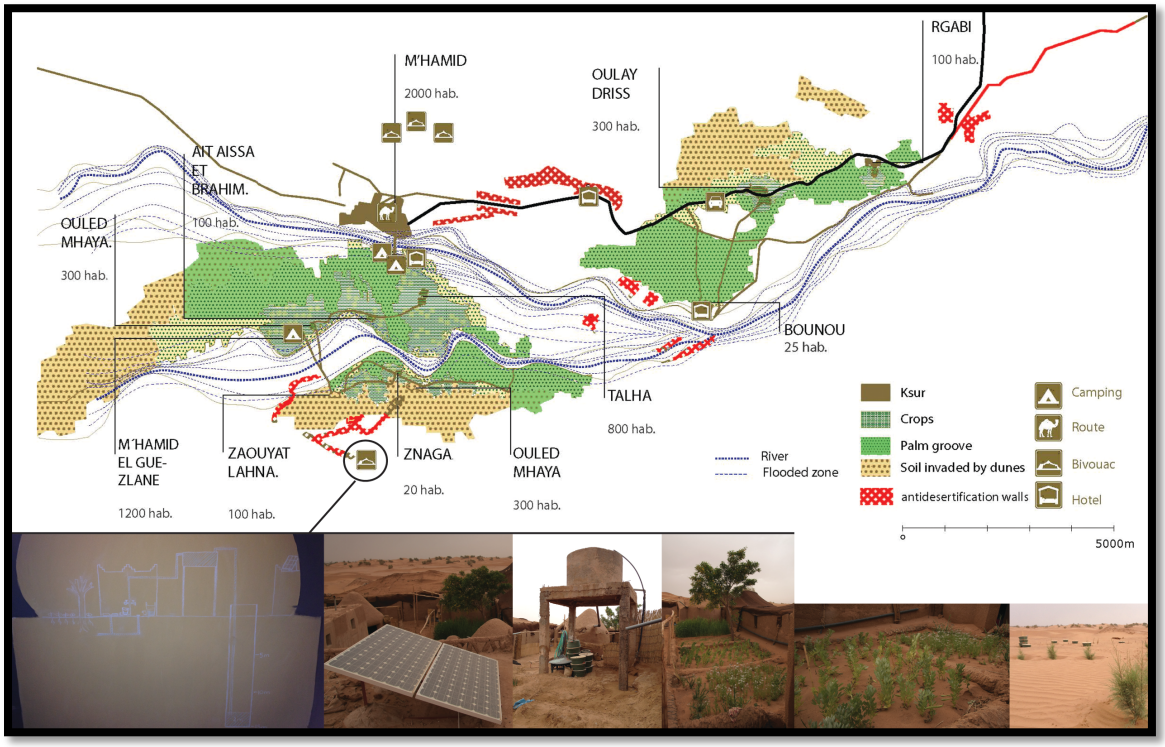

Figure 30: Beduin camps in M'Hamid (at the top); Taragalte Bedouin camp (at the bottom) (source: Author)

As illustrated in the picture (Figure 30), Taragalte Bedouin camp has been provided by a self-made integrated water management structure, composed by

well (functioning thanks to one solar photovoltaic panel) - water storage tank – toilets – underground natural filter – little farm from which they obtain some products for tourists' consumption.
At the same time they have started since 2007 a tamarisk planting project, thanks to the collaboration with the Sahara Roots, Dutch association, involving children living in the area to increase the awareness of the new generations about how to cope with wind erosion, desertification and to create shadow. The tamarisk tree project aims to demonstrate that the best way to fight desertification is not building hard barriers (as illustrated in fig 4), a short term strategy because becoming sand dunes themselves, but planting such highly drought resistant and alkaline-saline soils tolerant plants. In few years it can significantly contribute to decrease soil desertification thanks to plants roots and microclimate (Hebly and Hebly, 2010). So, from one side tourism just constituted one of the water consumption engines, from the other side, it represents nowadays the leverage and opportunity to demonstrate and build a new social-ecological equilibrium based on the sustainable use of the scarce resource thanks to imported (networks and) know how to put in practice. This seems really a clear small-scale example of how to build resilience (skills, differentiating incomes and options for survive) in a sustainable way.

7.14 Barriers to a water management paradigm shift and institutional traps

The 1990s marked by the risks of real water shortage were characterized by major changes with regards to political choices in the water sector. Choices to be made were perceived as being technical as well as socio-political. Morocco basically decided to manage the water resource in a semi private, semi public way (public-private partnership). As consequence of such choice the State delegated water management and treatment as well as electricity provision to private companies. Water governance is today more decentralized (through the creation of basin agencies) and to some extent directly managed by its users (through the implementation of water user groups and private drilling) and since King Mohamed VI succeeded to the throne in 1999, political pluralism and democratization have led to greater transparency and a very active civil society.

Nonetheless, problems of transparency remain with respect to anything related to the royal family and furthermore key decisions on the allocation and use of water continue to benefit the influential elite.

1. Corruption and Elites pressure

Agriculture has become a lucrative business. Political alliances of rural elites and the royal family have also changed but they are as important for political stability now as they were in the past. Numerous large landowners are now members of parliament or hold key positions in the food industry, which adds even more weight to these social networks. Rather than being just growers, many of them now control entire production chains. Due to the political and economic roles of these individuals and the progress of the democratisation and decentralisation processes, it can be said that the role and the composition of rural notables is thus undergoing major changes – traditional notables in many cases lose influence while investors increase their economic and political scope of action (Simon, 2011). Furthermore, the slowly improving legitimacy of the public institutions, the progress of decentralisation, and the emergent role played by civil society all suggest improvements in overall democratisation, and on the other, projects such as this public-private partnership (PPP) clearly restrict the role of public and democratic institutions in related to the project and reveal the predominance of the King's influence (Houdret, 2012). The consultation of public institutions at local and national levels has remained very limited, while, at the same time, public funds are being used to partly fund the PPP and, when the need arises, to compensate the private (royal) company (Houdret, 2012). At the local level, despite the general democratisation of the country, projects such as this private-public partnership (PPP) are contributing to exclude water users from political decision making and democratised water management. Despite this, recent socio-political changes during the 'Arab Spring', together with other, less recent developments, indicate new opportunities for previously marginalised actors to regain control over water, their livelihoods and some power. Although top-down management still prevails in most irrigation schemes and in the water and agricultural sectors as

a whole, opportunities to negotiate on individual interests and to set up new and effective cooperatives are being seized. Faysse et al. (2012) describe this process of farmers "voicing their opinion" and the development of political capabilities at local level. They also point to the opportunities for farmers, large and small, associated with the transformation of agricultural production processes and the increasing relevance of professional organisations (Faysse et al., 2010). With reference to corruption, it remains a major cause for concern in Morocco, in view of its persistence despite efforts made by the Government. Furthermore, the corruption perception index (CPI) for 2011 indicates that Morocco's ranking improved from 85th out of 178 countries in 2010 to 80th, with a score of 3.4 on a scale of = to 10 (African Development Bank, 2011). In particular, the global corruption report 2008 concerning the water sector (Transparency International, 2008) indicates that Morocco occupies the 72nd out of 179, with a score of 3.5 on a scale of 0 (highly corrupt) to 10 (highly clean). Despite the fact that such progresses are modest, they reveal in any case the efforts made by the Government to enhance the corruption prevention institutional framework, mostly through establishment of the Central Authority for Corruption Prevention (ICPC) in 2008 to coordinate, supervise and monitor corruption prevention policies.

2. Transparency

Even though the new constitution provides for the access of citizens to information held by public institutions, in practice the government did not grant access to official information to citizens and noncitizens, including foreign media (US Department of State, 2012).

3. Legitimacy

The legitimacy of local political leaders is limited and those formal institutions are not trusted to deal with the growing threats to livelihoods or to manage related conflicts. While, in recent years, financial support for local development initiatives, increased scope for action by the civil society, and timid reforms of the political system may have helped to weaken opposition movements

triggered by worsening living conditions, these changes have left the fundamental inequalities as they were.

7.15 Interviews with organisations in charge with water resources management in Morocco

Interviews with the Office Régional de Mise en Valeur Agricole Ouarzazate (ORMVAO), Office National de l'Eau Potable, Agence Urbaine Ouarzazate-Zagora, Province de Zagora, Province de Ouarzazate, Groupe de Recherche sur l'Impact, la Vulnerabilité et l'Adaptation au Changement Climatique au Maroc (GRIVAC), NGO Taragalte have been carried out to understand the water management context which the Souss-Massa Draa Basin Authority work in (Table 16). These interviews have been carried out as open question interviews and they were mostly focalised on understanding the degree of network and the connectivity of the Municipality. While a semi-structured interview has been carried out with the director of the Basin Authority.

Morocco			
No. Respondents from the organisations	Sector	Organisation	Specific Competences
1	Government	Office Régional de Mise en Valeur Agricole Ouarzazate (O.R.M.V.A.O.)	Created by Royal Decree of 22 October 1966 829.66, the Regional Office of Agricultural Development of Ouarzazate (ORMVAO) is a public institution with legal personality and financial autonomy and placed under the supervision of the Ministry of Agriculture and Maritime Fishing. It is responsible for: the promotion and development of agriculture in its area of action, the

			implementation of hydro-agricultural facilities and equipment, the management of water resources, training of farmers, support to credit agencies and conservation the environment.
1		Office National de l'Eau Potable (ONEP)	The Office National de l'eau potable is a public organization in charge of drinking water supply planning on national scale; studies, implementation and management of drinking water conveyances; management of water distribution on behalf of the communes; technical assistance in terms of water quality monitoring; pollution control of waters liable to be used for human consumption; studies, with the collaboration of concerned ministries, of projects' legal regolamentary texts necessary for the fulfillment of its task; sanitation studies in centers where office ensures water distribution on behalf of the communes; actively taking part in the studies of Sanitation Master Plan big towns at the national scale; training sessions organization of others.

1		Agence Urbaine Ouarzazate-Zagora	Urban Agency Ouarzazate - Zagora is a public institution with legal personality and financial autonomy, under the administrative supervision of the Ministry Delegate to the first Minister of Housing and Urban Development. It is governed by Decree No. 2-03-221 of 14 Rabia I 1425 (4 May 2004) on Urban Agencies Nador, Al Hoceima, Ouarzazate-Zagora, Oued Ed - Dahab - Aoussered, Errachidia Guelmim-Essemara.
1		Province de Zagora	Created after the division of the province of Ouarzazate by Decree: 2.97.281 01 of Al Hija 1417 corresponding to 9 April 1997. The province of Zagora has two urban districts and 23 rural municipalities.
1		Province de Ouarzazate	The province of Ouarzazate, created March 20, 1956, covers an area of 19,464 km2 and is divided into five urban districts and 32 rural. Its population is estimated at 499,980 inhabitants (General Census of Population and Housing, 2004).
1		Agence du Bassin Hydraulique Souss-Massa-	Established by Decree 2-00-480 of 14-11-2000 made under section 20 of the Water Act, the Water Basin Agency Souss-

		Drâa	Massa, is responsible for the management and protection capital water and public water.
1	Third parties (NGOs, NGOs, International Agency, Knowledge Institutes, Knowledge Institutes)	Groupe de Recherche sur l'Impact, la Vulnerabilité et l'Adaptation au Changement Climatique au Maroc (GRIVAC) (Université Cadi Ayyad)	Their research interests are on impacts of climate change vulnerability and adaptation strategies; winners and losers under global change; adaptation of water users to multiple stressors; implications of global change and urban-rural water linkages on local water management and usage; social perception and response to environmental change among farmers and enterprises, biodiversity valuation, ecosystem services and economic systems.
1		Taragalte	Taragalte concept is a partnership between a local team, local foundations and national and international institutions, all wishing to make a contribution to genuine development of the Moroccan Sahara region.

Table 16 : Interviews with organisations in charge of water resources management in Morocco

7.16 Adaptive capacity of the Souss-Massa Draa Water Basin Agency

The interest of understanding what will be the future trends of water resources and how to manage them has high-priority for the Souss-Massa Draa Water Basin Agency has sharply increased as stated by the Agency's director (Sabbar El Mustapha) for a set of reasons: (1) the succession of dry years as in the past, which may create a situation of shortage of water at the basin level in the future; (2) rising urban water demand; (3) the over-exploitation of groundwater; (4) the water pollution; (5) the siltation of the Mansour Eddahbi dam. In the last years, the amount of data available has been increasing due to the high number of national and international projects in this area. However, due to a lack of staff and the consequent inapplicability of some data management procedures, the ability in identifying gaps in the data and information and in filling them is still insufficient. In addition to this, such lack has a double side effect regarding: (1) the capacity of the Agency to manage the available data, (2) how to make sense of them, in particular because they are currently struggling with translating the scientific and probabilistic language into scenarios to enable them to make management decisions and develop effective investment proposals. On this line, the respondent to the interview considers the "Projet D'adaptation Au Changement Climatique Au Maroc (PACC)" as a great opportunity to develop and strengthen technical and analytical competences, in particular to enable them to undertake modelling of water resources based on climate data and their evolution.

As highlighted by the interviewed, the level of communication within the different sectors of the Water Basin Agency when defining and scoping a problem is generally low. This is due to a sectorial water management approach used within this organization. However, in case of drought or flood events, the definition of the problem and the following design of a contingency plan are done in a collaborative way. However, the complexity and the variety of problems the Water Basin Agency faces has pushed the same organisation to look extensively for collaborations to bring in perspectives from outside. For instance, as emerged from the interview, the depletion of groundwater led to the establishment of an action plan ("*contract de nappe*") over several years to

achieve the objectives in terms of water quality, enhancement and integrated and participatory management of water resources. In contrast, there is the fact that the Basin Agency is not interested in sensitizing people and local associations about the scarcity of water resources because as argued by the director the public is too ill informed to be involved. This statement may be interpreted in light of the peraphs too large margine of autonomy of the Agency director in deciding priorities and management objectives. Indeed, from the survey, it emerged that climate change and how it will affect the water resources are currently seen as a key topic for the River Basin Agency. Furthermore, the definition of a more collaborative framework between the Water Basin Agency and other government organisations is under development within the PACC projects for the construction of an early warning system by 2014. The respondent sees this as an opportunity to build up a network of stakeholders around a common vision on the issues of climate change and the implementation of adaptation measures.

Notwithstanding, the two interviewed representatives of the Agence Urbaine du Ouarzazate and the Agence Urbaine du Zagora stated to be alone in doing their work and to encounter difficulties in coordinating and sharing information with local associations as well as with higher government levels. In turn, the director of the Draa water basind authority recognized that this activity is requiring to the Agency important efforts in terms of developing capacity to enhance both the internal and external communications due to a not so well-established and efficient communication system, but also because it is not so clear to them who does what. Despite the fact that the Basin Agency is preparing itself for future climate change, the director's responses remain within a "business as usual" context since he is still focused on current weather impacts only. As result from the interview, the Agency is currently stuck and sticks to well-known measures. On one hand, the Agency has to deal with the lack of coherent sector strategies. Agriculture, industry and drinking water make their future planning strategies without consultation of the other sectors as well as the Moroccan government national strategy whose emphases currently still lies on the expansion of supply (the construction of the new dam and the implementation of Green Plan project in the Draa Valley). In particular the director dissents from the construction of

the new dam as he thinks that the Mansour Eddahbi dam has already created too much damage to the Draa valley thus he is personally prefers reversible measures over irreversible ones. On the other hand, the Water Basin Agency is aware that an infinite augmentation of water supply is not possible in order to meet the steadily growing demand over the coming decades. Notwithstanding, the effectiveness of the Water Basin Agency in developing clear and actionable solutions for this problem is not sufficient yet. In parallel, as underlined by the interview with Office Regional de Mise en Valeur Agricole de Ouarzazate (ORMVAO), this is probably due to the fact that even though the agriculture ministry is trying to convince farmers to cultivate drought tolerant plants but it cannot oblige farmers to abandon beetroots, melons, and other water intensive plants that are sold with high profits on the international market. Henceforward, the adaptation to less water intensive crops seems to be possible through managing demand via prizes. Once water becomes too expensive, users will start to use it less. On this line, the water price should reflect its scarcity. Nonetheless, there is a divide of financial capacity between big export oriented farmers and small and medium size farmers, which makes uniform conditions for both groups an impracticable solution. This controversy also seems to affect the work of the river basin agencies. While in theory the Basin Agency wants to install a regime where everyone has to pay for water, in practice the Agency is very reluctant to enforce such a regime. The main argument against the enforcement is a lack of resources, even though the Basin Agency is aware that control of the demand is becoming increasingly important. Moreover, the river basin agencies complain that even though they should control the (potentially) illegal pumping activities in the rural areas, they do not have enough employees (the agencies employ a so-called “water police”) to cope with all their planning assignments to face also this problem. In addition, the Authotity does not have the resources to enforce penalties against illegal water users. In addition, the respondent states that farmers are too poor to pay the prize anyway and that the enforcement of this regime would drive them into legal confrontations that are not beneficial to anyone. Another issue that was raised along the interviews is the lack of any monitoring system. However, while asking if there is a sort of monitoring system of the incomes and outcomes concerning active projects and/or implemented activities since the Basin Agency is an independent

organisation and it has its financial autonomy such that it should be self-supporting with regards to its income and expenses, it became obvious during the interviews that this is a sensitive subject[39]. The first answer was that the Agency finances its organisation through incomes from water management. When questioned further, he admited that these revenues do not really cover the whole expenses. This is probably due to the inability of the Agency to collect fees for water management and sustain the organisation hence the central state subsidizes the river basin agency to a large degree.

7.17 Barriers and Opportunity to Adaptive Water Management Implementation

As we have seen along this chapter, in order to cope with competing values, political and economic interests in the basin, incresing water scarsity, natural hazards, in particular drought, and climate change, an adaptive, multi-level, multi-sectorial, and collaborative governance and management arrangements are needed.

The data collected during the interviews have been summarized and respectively assigned to the related cells of Table 17, applying the developed conceptual framework (Table 17). The red cells refer to the absence of any activity aiming at building/enhancing the relative capacity, while the yellow ones mean that there is an ongoing activity or interest in upgrading these capacities; the green cells show that the organisation already has some adaptive capacity to respond to the related dilemmas. The grey cells, instead, mean that it was not possible to collect data regarding such capacities or the amount of information collected is not sufficient to assess the organisational adaptive capacity.

[39] A transparent and public budget of the Souss-Massa Draa Basin Agency is not available

What/when		PROBLEM FINDING			PROBLEM SHAPING		PROBLEM SOLVING				DECISION TAKING		
		Variety of problem frames	Capacity to collect and manage data	Capacity to predict problems from collected data.	Capacity to understand and outline the dilemma's borders	Proactivity	Diversity of Solutions	Clear mechanism for enforcing rules	Preventing rigid persistance	Organisational capacity to inform about their decisions and of the procedures to implement them.	Responsiveness	Monitoring and evaluation	End-user oriented languagge
LEARNING CAPACITY (organisational)	Ability to deal with everyday and crisis situation												
	Willingness to experiment												
	Institutional memory												
	single loop												
	double loop												
	triple loop												
	Trust												
LEARNING CAPACITY (individual)	Willingness to change and to adapt												
	Preparedness to experiment												
	Continous access to information												

What/when		PROBLEM FINDING			PROBLEM SHAPING		PROBLEM SOLVING				DECISION TAKING		
		Variety of problem frames	Capacity to collect and manage data	Capacity to predict problems from collected data.	Capacity to understand and outline the dilemma's borders	Proactivity	Diversity of Solutions	Clear mechanism for enforcing rules	Preventing rigid persistance	Organisational capacity to inform about their decisions and of the procedures to implement them.	Responsiveness	Monitoring and evaluation	End-user oriented languagge
LEARNING CAPACITY (individual)	Willingness to change and to adapt												
	Preparedness to experiment												
	Continous access to information												
SHARING AND NEGOTIATING	Availability of the data to others												
	Connectivity												
	Degree of network												
	Multi-actor; multi-sector; multi-level (Vertical and Horizontal)												
	Ability of an organisation to communicate and debate ideas and solution to problems among different agencies												
LEADERSHIP													
CAPACITIES	Human Resources												
	Financial Resources												
	Technological Resources												

Table 17: Assessment of the organisational adpative capacaty of the Basin Authority (source: Author)

The Basin Authority as shown by the table 17 has a low capacity to adapt its routines. The present rigid organisational structure of the Basin Authority leads this organisation to reinforce existing relationship as well as to reproduce routines and continue to adopt habitual way of thinking and working rather than integrating.

Furthermore, as we have seen in sections 7.8 and 7.12, various national policies are focused on this part of the country generating disagreement, in particular by the director of the Water Basin Agency. Although it is clear that not all water-related problems can or should be solved at the river basin level, however coordination of the different policies should represent common goal. This would allow reducing possible trade-offs originated by a lack of systemic vision of the water resource. Of course, not all situations can be resolved with win-win outcomes, at least in the short term. Trade-offs and compromised is often the necessary outcome. Conflict management involves both social change and social learning. Developing strategies at the river basin level would allow taking advantages of possible synergies between different policies increasing their effectiveness, especially in a context such as this one where the last giant national work, the dam, has generated so many impacts. Working at the river basin level scale would ease collaboration between different organisations working on the same resource, water. Therefore, adopting an adaptive water management approach within this context implies to develop a mechanism of planning and implementation of policies based on participation, which would reduce trade-offs and conflicts related to water management.

As follows, at least at the basin level, it means that involving civil society actors within the problem management process would foster Basin Authority's legitimacy, as it engages confidence and active social participation in transformation. The need to develop a local conceptual model oriented to enhance horizontal communication and coordination within the Basin Authority as well as between the latter and the other organisations operating in this context must be pointed out. Such new water management model would favour the development of relationships of trust both between individuals and groups within the organisations, and between the organisation and its

stakeholders, enabling flexible ways of working and promoting the generation of more ideas and initiatives. In this line, the creation of a working system based on cooperation requires that an organization develops its own networking capabilities and consequently modify the organisational routines.

External collaborations and participation in projects focused on improving the abilities of the Basin Authority and bringing in perspectives from outside the organisation, such as the PACC project (described in section 7.16), promoted by director of the Basin Authority, may create that window of opportunity to activate this process of change, at least within the same Basin Authority. Indeed, because of what Lee (1993) includes between the barriers that are limiting the long-term effectiveness of the AM approach and describes as "resistance from managers who fear increased transparency", the restrictive leadership characterzing the Basin Authority does not support a bottom-up approach, thus holding back the enhancement of organisational routines, such as those regarding coordination and sharing activities. However, the process of improvement of data and knowledge management launched by the Water Basin director opens up important opportunities for sharing, even though maybe not in the short-term, due to the leader's unwillingness (or fear). It must be kept in mind, though, that having better data management system, computers, and etc. do not guarantee that information will be shared and knowledge will be developed. As far as we have seen until now, the ability to share and develop knowledge lies in the feature of the day-to-day routines and in the capacity of leader(s) or champion(s) of change to transform (within the organisation as well as by sharing externally) data into knowledge and further into learning as iterative action. Furthermore, as wisely highlighted by Ackoff (1989), having a better knowledge management doesn't necessarily mean that system designer and operators will provide leaders with the right information because "*they have no criteria for determining relevance and the degree of accuracy and reliability of information required by managers*". This underlines that the capacity to implement an adaptive water management goes first of all through sharing common language and goals. Linked to this, there is the need to develop an iterative process of monitoring and evaluation of policies oriented to

implement such adaptive management and that, therefore, would allow the organisation to redefine objectives and improve strategies overtime..

CHAPTER 8: CONCLUSION AND LESSONS LEARNT

The case studies that have been analysed in the previous chapters provide important element for reflection and highlighting key issues on water management in a globalised world.

The case study of the Draa Valley shows how the resilience of the population was mainly due to their flexible lifestyles (temporal migration in case of droughts) (Rachik, 2007), a deep local environmental knowledge (respect for ecological thresholds), a multi resource economy and a common participative resource management (Casciarri, 2006; Breuer, 2007). These strategies have conferred long-term sustainability to the regional soci1-ecological system for centuries. However, since 1972, centralized water management command and control practices deeply transformed the centenary old fragile but resilient, regional equilibrium (Casciarri, 2003). Different strategies to cope with droughts and increasing desertification rates have focused almost exclusively on short-term adaptation. New centralized solutions, and local patterns of development (mainly energy, agriculture and tourism), are dependent on top-down, non-participative decisions, and on global markets fluctuations. The increasingly unsustainable uses of water upstream in the valley, fostering the role of city upon the regional chain of oases, seems not to take into account the demand for water by of Southern oases. Thus, the regional social-ecological equilibrium, and its sustainability, is in danger.

The Bolivian case study is an example of unsustainable transformations of the local social-ecological system due to the flourishing of the global quinoa market, which threatens the Municipality of Tomave, already prone to droughts, to even higher risks. This market-dominated shift in the functioning of the system generates a mixture of benefits and risks for the entire regional socio-ecological system – increased well-being for local farmers, but undermining wide-scale rural resilience. Indeed, if ecosystems, economic and cultural functions of this rural region are jeopardized, the overall system resilience will be compromised. Thus the Bolivian case study shows how cross-scale interactions and drivers may produce real problematic trade-offs for rural communities and how

resilience trade-offs can occur within a scale due to stark heterogeneities in adaptive capacities. The advantage for maintaining resilience of the agro-ecosystem lies on local organizations. As market demand is not linked to local ecological carrying capacity, decisions affecting sustainable development and avoidance of ecological critical thresholds rely on dialogue between local farmers, local governmental organisations and the global market administration. The responsibility (and the opportunity) to manage these trade-offs need to be placed on local organisations. In fact, local government plays an important role in finding solutions and developing mechanisms to reduce vulnerabilities of the rural-urban systems by aiming at providing equitable opportunities in cross-scale interactions.

These two case studies suggest that it is necessary to deal with shocks and stresses at multiple scales, which have cascading impacts at multiple scales, and where trade-offs occur, and stressing the fact that resilience should not be confused with the positive normative connotations of sustainability (Derissen et al., 2012) as resilience 'per se' is not the goal but sustainability. Because of this, I argue that a sustainable transformation should be the long-term goal, operationalized through the management of different scales and approaches to resilience. Hence, sustainable adaptations to droughts (and more in general to environmental and climate changes), in order to increase dryland resilience, require improving or at least maintaining the whole regional ecosystem functions and services. On the contrary, short-term speculations built around external markets may decrease both ecological (because of possible over-exploitations) and social (because the dependency from external resources) resilience, resulting in unsustainable patterns of adaptation and development. Both in Morocco and in Bolivia sustainable drought adaptation strategies should develop conditions for long-term resilience of regional social-ecological systems. Such conditions are: (1) a balanced development of urban and rural systems across the region (and globally); (2) the adoption of better adapted crops that are drought and salt tolerant in the Moroccan case, contributing to local food production, security, and oases conservation; (3) the implementation of a more organic farming in Bolivia; (4) the adoption of decentralized and adaptive water management by building capacities and empowering local and

regional water organizations.

Both case studies show that in order to respond to present and future challenges, water organisations should build strategies to adapt in a timely and effective manner as well as reinforce rather than weaken resilience.

As follows, in chapter 4, I strive to make the case for expanding organisational adaptive capacity and improving upon previous assessment efforts by bringing together insights from business, organisational behaviour, and climate change context. I show that adaptive capacity is mostly seen as a black box and that ways to operationalize it are not clearly expressed. Thus, in chapter 5 outlines a framework for improving organisational adaptive capacity assessment.

Such framework (figure 31) provides a set of capacities that water organisations should have to enable a process of transformation of organisational routines and shows how those capacities could be operationalized along the management process to build organisational adaptive capacity.

What/when		PROBLEM FINDING			PROBLEM SHAPING		PROBLEM SOLVING				DECISION TAKING		
		Variety of problem frames	Capacity to collect and manage data	Capacity to predict problems from collected data.	Capacity to understand and outline the dilemma's borders	Proactivity	Diversity of Solutions	Clear mechanism for enforcing rules	Preventing rigid persistance	Institutions capacity to inform about their decisions and of the procedures to implement them.	Responsiveness	Monitoring and evaluation	End-user oriented languagge
LEARNING CAPACITY (institutional)	Ability to deal with everyday and crisis situation	✓	✓	✓	✓	✓	✓	✓	✓	✓			
	Willingness to experiment	✓	✓	✓		✓	✓			✓			
	Institutional memory	✓		✓	✓		✓					✓	
	single loop	✓	✓				✓			✓		✓	
	double loop	✓		✓	✓		✓	✓		✓		✓	
	triple loop	✓		✓	✓		✓	✓	✓	✓		✓	
	Trust		✓	✓						✓		✓	✓
LEARNING CAPACITY (individual)	Willingness to change and to adapt	✓	✓			✓	✓		✓		✓	✓	
	Preparedness to experiment	✓		✓	✓	✓	✓		✓		✓	✓	
	Continous access to information	✓	✓	✓	✓		✓					✓	✓
SHARING AND NEGOTIATING	Availability of the data to others									✓	✓	✓	✓
	Connectivity			✓	✓	✓	✓			✓	✓		✓
	Degree of network	✓	✓	✓		✓		✓	✓	✓	✓	✓	
	Multi-actor; multi-sector; multi-level (Vertical and Horizontal)	✓		✓	✓		✓			✓	✓	✓	✓
	Ability of an institution to communicate and debate ideas and solution to problems among different agencies	✓		✓	✓		✓			✓	✓		
LEADERSHIP		✓		✓	✓	✓	✓		✓			✓	

Figure 31: Table 8: What/when. Correspondences between capacities and process attributes (source: Author)

In chapters 6 and 7 the framework is applied to analyse and interpret the solutions adopted for water management in the two case studies areas in Bolivia and Morocco. Ultimately, these chapters, in sections 6.17, 6.21 and 7.14, 7.17, aim to understand what are the barriers in the water management context hampering the implementation of an adaptive water management and to analyse opportunities to overcome such barriers.

As we have learnt, the incapacity to transform organisational routines as the context is changing leads to both the construction of barriers and the inability of organizations to support the process of society change. This is due to the fact that a system, as a whole, tends to seek a new equilibrium generating problems and opportunities at the same time.

Furthermore, organisations being part of the system continuously interacts with its environment, and through these interactions organisations are influenced and can influence. This underlines the fact that as part of a system (network) of organisations, an organisation aiming at building and/or enhancing its own adaptive capacity, as it is for the two analysed water organisations, should not focus on developing its internal capacity only. Instead it should strive to enhance the capacity of the entire network of organisations with which it interacts, as the adaptive capacity of a system requires a synergic effort of all its components. An organisation should be permeable enough to allow data, information, and perspective coming from outside to flow in order to support the routine transformation process and promote creativity and innovation, and to become organisation's own knowledge and experience. Indeed, the process of collecting data as well as information and transforming them into knowledge is a serviceable definition of learning (Sussman, 2004). However, the development of a working system based on cooperation requires first of all that an organization acquires skills and adapts its routines to the new working method since the current routine system is not fully open to bring in perspectives from outside. Furthermore, the development of a participatory process of planning and implementation of policies would help to reduce the trade-offs and conflicts related to water management. Linked to this, the development of a system for monitoring and evaluating implemented policies organization can contribute to build an iterative mechanism so as to allow a redefinition and improvement of such policies.

8.1 Suggestions for improving organizational adaptive capacity

As discussed in the previous chapters, the changing context and the need to respond to such changes by applying more adaptive water governance and management system requires that water organizations to adapt and enhance their routines.

With reference to this, there are a number of enabling processes and other means that can build or strengthen adaptive capacity within organisations. As follows, two different approaches to enhance organisational adaptive capacity are of particular relevance: (a) building internal adaptive capacity; (b) and building sensitiveness to "make" or "buy". The former approach is mainly about the idea to acquire skills within the same organisation; while with "make" or "buy" solutions I intend the ability of an organisation to evaluate advantages and disadvantages of developing skills internally to the organisation and of acquiring capacities using networking, cooperation, and consultancy activities, and choose the best option to get skill. These two approaches should not be seen as mutually exclusive (choosing one does not exclude the possibility to adopt also the other one in another phase), in fact they should be considered as fully integrated. For instance:

(a) Building internal adaptive capacity (individual and organisational):

- Addressing time and resources to analysis (combining reductionist analysis approach with "system thinking" approach (Morgan, 2005)), experiment and do things differently to move beyond "business as usual" routines toward improved procedures and more effective ways of working;
- Integrating learning from past experiences with forward-looking exercises such as scenarios and assessments to make development more resilient to future emergences (droughts and/or climate change);
- Integrating short- and long-term view and therefore prioritizing measures;
- Balancing planned strategies with aligning language and objectives

of national and international decision-makers' agenda;

- Developing capacity to act as "bridger" connections in order to establish networks and cooperative working environment;
- Favouring (formal and informal) connections between different individuals and teams across an organisation;
- Gaining skill by addressing room within the organisation and among organisations for reflecting critically, thinking creatively and sharing knowledge;
- Developing the ability to monitor, evaluate and measure the impact(s) of policies and programmes implemented;
- Developing/Enhancing communication strategies and tools using also a more oriented end-user language.

(b) Building sensitiveness to "make" or "buy":

- Cooperating with other organisations to create shared understanding or developing interdependent (multi-level and multi-sector) strategies. This can also set favourable conditions for the development of a platform for common learning and exchange of experiences.
- Collaborate with organisations with a higher level of adaptive capacity might contribute to take the next step; in the meantime cooperating with organisations having the same adaptive capacity tier might be helpful not to feel alone in facing this challenge;
- Understanding and mapping the dynamics and the interrelationship of the system in which an organisation operates.
- A significant aid could come by donors since numerous international cooperation projects are developed in the two case studies. The adoption by donors of less rigid project frameworks and therefore less pre-fixed outcomes requirements may provide more room for experimental activities within a cooperation project.

8.2 Barriers to develop/enhance adaptive capacity of an organisation

Although the water organizations in Bolivia and Morocco demonstrate the willingness to enhance their routines in order to respond to opportunities and dilemmas in their respective environment, the assessment of the organizational adaptive capacity carried out by applying the developed framework identifies some criticalities within the operative processes of adaptive capacity in the two different water organizations. These criticalities are explored here:

1. Organisational Learning Capacity in the "Process"

As result from the interview with the Municipality of Tomave in Bolivia, it was really difficult to discuss the challenges of longer-term adaptation to droughts and to environmental changes. Firstly because the distinction between mitigation and adaptation was not so clear to the technicians' team manager and this was generating misunderstanding. Furthermore, even though they are conscious that they will have to face future droughts because they have already experienced some, their attitude is strongly oriented towards responding to impacts (short-term planning) rather than developing long-term measures to face them.

Besides, even though the topic of climate change is key in the national agenda, at the local level people are more focused on current weather conditions and disasters. Furthermore, the municipal technician prefers to frame discussions around extreme weather or ENSO than climate change. This is due to the fact that translating the scientific and probabilistic language into scenarios that enables the organization to make management decisions and develop effective investment proposals within the terms on which the organisation is running, requires highly skilled personal and is costly. Translating and developing proposals are seen as one of the main barriers by the Municipality. Its clear from the interviews that despite having experienced droughts, the officials of the Municipality of Tomave miss the fact that decision timescales can mean that when impacts occur it could be too late to respond. In this line, the unfamiliarity

with proactive and long-term decisions of the Municipality leads to “business as usual”. In other words, when things go wrong, the Municipality (as well as the Moroccan Basin Water Management of the Souss-Massa Draa as we will here later) tends to apply familiar, official rules and solutions experienced in the past. This contributes to make the water organisation static and vulnerable to current as well as unexpected problems. Therefore no learning process is activated. The development of a culture of monitoring and assessment of the organisational activities at all levels (internally and externally) should be instead encouraged and implemented on a regular basis. An organisation monitors its progresses in accomplishing goals (e.g. cope with current, unexpected, future problems) and assesses its effectiveness in achieving the expected results can learn and make changes coherently with the assessment results. Monitoring practices enhance the potential for gaining organisational experience. Based on the assessment results, the best organisational level to respond promptly to a dilemma can be identified, as discussed in section 5.10. As follows, this underlines a strong link with “leadership in the process”; indeed, leaders and champions of change may act as a boost to trigger single, double, and triple learning loops in order to enhance or develop new routines to cope with different dilemmas and uncertainties.

The Moroccan case study shows another barrier, related to the possibility that even when an organisation, such as the Souss-Massa Draa Water Basin Agency, has embedded climate change adaptation into its main operational agenda, its programmes have not embedded yet the activities necessary to address longer-term impacts. In addition, there is another barrier, which refers to the inability to imagine what a changed future might look like thus the Agency is experiencing some confusion in envisioning and understanding the implications of climate change. Hence clear and strategic actions are not being implemented. This can be due to the organisational decision making processes as well as e to the ways of thinking, which are grounded on responses to current weather and have not yet acknowledged of the implications of future droughts events (and climate change) as demonstrated by the overexploitation of underground water in the Draa Valley. “Business as usual”, short-term planning prioritisation, as well as insufficient room for assessments, are fundamental barriers to adaptive

management. Although the director of the Basin Agency considered positively the "adaptation agenda", it was not possible to distinguish clearly the political agenda's goals from the operative agenda's goals.

It is worth pointing out that leaders are certainly important in legitimising adaptation actions. However they do not determine whether change is successful in isolation from other factors. On this line, the Municipality of Tomave seems to reflect a growing understanding that adaptation will not be as easy to achieve they had thought. For instance, they recognise: (1) lack of skills and knowledge; (2) the need to overcome internal scepticism (about climate change as well as the goodness and benefits of some activities); and (3) lack of financial and human resources. With reference to the first two barriers, it is necessary to make a distinction between scepticism and lack of skills and knowledge. Scepticism of people (they might be leaders, decision-makers or other people who might need to change how and what they do in order to acquire adaptive capacity) refers to something that we can define as subjective. However, scepticism as other barriers that can be clustered together under the umbrella of subjective barriers, such as attitude to risk, political inclinations, etc. is difficult to measure. Nevertheless, it is crucial to understand subjective behaviours because these may lead to underinvestment in capacity development. On the other hand, skills and knowledge are different from scepticism as they can be assessed objectively.

What is resulting from the two case studies is that learning processes have hardly begun. This is probably due also to the fact that there is not a real monitoring and assessment of policy and programmes implemention within the two organisations. Thus, the lack of these two activities implies an absence of those feedbacks that may lead to behavioural adjustment in an organisation.

2. Individual Learning Capacity in the "Process"

The Municipality of Tomave has as yet done little, however as shown by the Councillor during the interview, the Municipality is starting to recognise that a change might be needed and that in the Municipality there is the will to do something. However, such condition clearly shows that individual change

agents themselves see the need for change, but often believe that the most effective way to advance, is through external intervention (national and/or international). Therefore, even though there is a propensity of the municipal technicians to bend the rules, both the willingness to improve and preparedness to experiment is too low to trigger a change and have direct impacts, for instance, on the capacity to design solutions different from those usually implemented. According to this, the lack of skills (e.g. no technical ability to identify meaningful, reliable and usable data) and knowledge (for instance, the capacity to recognize and interpret early sign of emerging problems) can cause indeed inability or unexpected emergences. Nonetheless, once such lack is recognized it can be tackled. However, in the two case studies, it was not possible to understand how far this low level of willingness to change and preparedness to experiment refers to a low individual commitment, on to more general conditions.

3. Sharing and Negotiating in the "Process"

The Municipality of Tomave is aware that external collaborations and projects are an opportunity and that it is necessary to push itself to be connected, engaged, and to avoid being more isolated than they already are. Despite of this, its capacity to be porous and to permit information, ideas, and perspectives from outside to find their way into the organization is still low. This explained by the attitude of donors' organisation, in fact, nowadays, also the no-profit sector has changed and requires a much stronger commitment of the Municipality to support it. In addition, cooperation projects, which commonly lasts 3-4 years, cannot solve the entire problem, thus they should be seen by the Municipality as a tool to accomplish some tasks of a wider project lead by the local government itself. This means that it is not sufficient for an organisation to be open to collaborate with others, but because collaborating is a costly and time consuming activity, an organisation should be extremely aware "of what" and "to what" it wants to collaborate and thus invest the necessary resources. Directly linked to this, there is the fact that the Municipality of Tomave, which is characterized by a low adaptive capacity, tens to take fewer decisions with

extended lifetimes (which can be defined by a minimum ten years from the beginning of decision process to the end of the lifetime of the decision) as shown by the absence of any vision or long-term goal in the PDM and the POA.

Another issue refers to the inability of the Municipality to organize collaboration among indigenous communities and to create a cooperative and synergistic environment in order to support a strategy of development for the Municipality, based also on mitigation and adaptation to future risks, such as drought risk. This can be due to the fact that, on the one hand, each indigenous community seeks its own interest, creating a situation that does not favour participation nor fosters management capacity. On the other hand, the Municipality is unable to create awareness of how interdependent the single communities are and how sharing a common goal would maximize the resources the Municipality holds.

With reference to the Moroccan case study, the top-down management and the strong hierarchical organisation, which characterizes the River Basin Agency, do not facilitate group interactions within the same organisation. Therefore, this may result in the creation of barrier to the flow of information, and in difficulties to stimulate creative ideas and innovative initiatives. Furthermore, the capacity to network and cooperate should be considered as an internal ability conveyed by daily routines opened to share information as well as perspectives with the external environment. Thus, in an environment, such as in the Moroccan case, where there is a large number of organisations involved in the water sector, it is critical for an organisation to show its ability in the daily routine in order to decrease the possibility of conflicts of attributions. The multiplicity of conflicting actors reduces the scope for an easy implementation of policies. The claim of the Moroccan River Basin Authority of the need to collaborate with other organisations to achieve its goals (e.g. facing water pollution or over-exploitation of groundwater) creates the condition (the enabling environment) for a cooperation and networking activity. However, once a cooperative activity between multiple organisations has been put in place, it is required that an organisation keeps it lively by influencing such environment or by being influenced by it so as to favour relevant learning processes. Nonetheless, the lack of trust as shown by the two cases (indigenous communities towards National Meteorological Office and the director of the

River Basin Agency towards stakeholders) results both in the absence of a space to exchange ideas and initiative and in problems of communication, which may become even more serious during emergencies.

4. Leadership in the "Process"

Leaders and leadership are often considered as key factors in fostering organisational adaptive capacity, in legitimising action(s) on an issue, and in providing resources to deal with it. However, as demonstrated by the Moroccan case study, leaders can act as filters of knowledge, disregarding information conflicting with their own vision, and further they might restrict the range of available actions that can be taken. Furthermore, the lack of awareness of the relevance of informing people about the water resources scarcity, is leading to underinvesting in people's development capacity, which instead should be part of the mission of the Basin Authority. In the meantime, the Moroccan case study shows how a leader, as the director of the Water Basin Authority, interested in increasing the adaptive capacity of his organisation, should be focused on understanding the whole pattern related to decision-making process, not just a part of it, in order to identify issues requiring additional information or a different approach (e.g. to solve illegal pumping practice) and promote learning.

Whereas, in the Bolivian case study, even though the Councillor legitimised the process of innovation related to the European project carried out by the Italian NGO ACRA, he was not himself to drive the change within the organisation. Instead, he delegated the technician's team manager. Despite the fact that the team manager is sharing Councillor's idea, because his fearfulness of making mistakes and his feeling of working in a culture that is sceptical, he is actually fostering a reactive approach. This highlights on the one hand the relevance of leaders and of their ability to adopt diverse types of leaderships (e.g. democratic, visionary, authoritarian, etc.) to promote a change or to face problems in order to fit within the (changing) context or situation. In other words, there is the need of a *transformational leader*[40]. The extent to which

[40] The concept of transformational leadership was initially introduced by James MacGregor Burns (1978) and later expanded by Bernard M. Bass upon Burns' original ideas to develop what

people in charge are effective in changing their role is among the most relevant factors to build adaptive capacity. A strong individual commitment is needed, since as we have seen in the paragraph 6.20, managers' task is usually to achieve the goals that are defining the agenda. Goals to be achieved, however, need to be feasible and realistic to overcome scepticism and resistance.

8.3 Barriers in the Water Governance

Besides the barriers related to the capacity of an organisation to enable a process of change, such processes of transformation can be restrain by political, social, economical and administrative mechanisms and institutions influencing the water management. Indeed, such wide range of interests related to water resources cause numerous and significant externalities in many realms that are critical for development, such as those illustrated in the two case studies: agriculture, energy, urban population growth. Therefore, water policy needs to face a high degree of complexity, given the multiplicity of actors, motivations and stakes (OECD, 2011). This raises critical considerations for effective governance.

More effective water governance is needed in order to respond to uncertainty and increasing scarcity, and improve the linkages between ecosystems through which water and social systems interact (Folke, 2003). According to this, as discussed in the section 4.1, effective water governance must encourage participation in the process for deciding how water is used; promote innovation and learning among stakeholders, and foster adaptation to changes in water availability (Currie-Alder et al., 2006).

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is today referred to as Bass' Transformational Leadership Theory. According to Bass, transformational leadership can be defined based on the impact that it has on followers. Transformational leaders, Bass suggested, garner trust, respect, and admiration from their followers.
In their contribution "Transformational Leadership", Bass and Riggio (2008) explained: *Transformational leaders…are those who stimulate and inspire followers to both achieve extraordinary outcomes and, in the process, develop their own leadership capacity. Transformational leaders help followers grow and develop into leaders by responding to individual followers' needs by empowering them and by aligning the objectives and goals of the individual followers, the leader, the group, and the larger organization.*

Although some common characteristics of water governance can be highlighted in the two case studies, water governance responses should not be necessarily the same in Morocco and Bolivia. The regional context is indeed relevant and influences how water governance is perceived and structured locally as well as it determines what can be done. Such differences should not be considered as a limitation. On the contrary, these give us the chance to better understand the concept of both adaptive governance and how and why barriers are built up. The implementation of effective water governance and the scope to improve it are relevant topics in the political agenda, however, across the two different contexts, common and specific obstacles to achieve it can be recognized.

Within the two case studies it was possible to identify six barriers that seem to hamper the achievement of the full range of benefits foreseen by the AWM approach changes: (1) institutional legacy; (2) fragmentation; (3) transparency; (4) lack of tools; (5) legitimacy; (6) corruption and elite pressure.

1. Institutional Legacy

The lack of a national modern water law in Bolivia creates a condition in which water resource is governed by focus on the regulation of uses for each single sector of consumption (e.g. agriculture, energy and domestic). As a result, different ministries and public agencies are involved in water policy because of the interconnectedness of different issues (agriculture, energy, etc.). This produces a fragmented policy with the inherent risks that the “silo” approaches become real due to the absence of inter-ministerial coordination. We remind here that a silo approach is the lack of collaboration and standardization between business units, department or sectors.
Thus, adopting a systemic approach in order to overcome the sectorial fragmentation of water-related tasks across the different regulators is necessary. Institutional framework should be analysed for two specific reasons. On the one hand, it is useless to prioritize water users since rights are not always clearly defined; and, on the other hand, such institutional framework is the main reason for the disjunctures between water policies and planning. This is because, it is still characterized by a large number of rules, which are

contradictory, to the effects on quality and quantity of water. Therefore, as highlighted by the study "Water Governance In OECD Countries: A Multi-Level Approach" carried out by the OECD (2011), co-ordination and consultation mechanisms must be developed to overcome the barriers to effective implementation on the ground, which implies managing the explicit or implicit sharing of policy-making authority, responsibility, development and implementation at different administrative and territorial levels. These mechanisms emphasises how an institutional framework characterized by a sectorial regulation does not fit within complex and interacting social-ecological systems. Furthermore, they underline the role played by an institutional legacy in restraining the processes of transformations and highlight that a more adaptive and flexible framework should put in place in order to face the challenges posed by future droughts and climate change.

In turn, the Bolivian law 2878/2004 was issued to prevent abuses of large users (industries, mining sector, companies providing municipal water but also because of the elite pressure of irrigation farmers association, who will continue defending its rights[41], shows how a law with its strong regulatory impact can be the cause of a rigid and unequal water management system. As a consequence, stakeholders seek to assert control over water in order to protect their values and interest. A polycentric participation (multiple organizations and stakeholders involvement) would be needed instead in order to determine how water is used at different levels and time. Kurachi et al. (2006) claims that equity includes, but is not limited to, equal provision of resources; fair disclosure of information; distribution among stakeholders of profits derived from natural resources, etc. Corbera et al. (2007) have indicated that equity lies in access, decision-making and outcomes.

2. Fragmentation

The Bolivian case study shows how unclear definition of power and functions of the different sectors and administrative levels, which conflictually overlap, generates the inability to place responsibility and accountability in the hand of

[41] Although putting at a disadvantage other farmers (see section 6.17).

one actor resulting, therefore, in water governance failures. As a consequence of this, the improvement in coordination between and within levels of governments is critically needed, to avoid generating a muddy system but instead to benefit of the overlapping and redundant institutions, which may increase the capacity of a system to provide more articulated responses to a problem (Walker and Salt, 2006). Therefore, as Saleth and Dinar (2000) state, a balance between centralization and decentralization to carefully craft institutional arrangements are needed at different levels to achieve both local flexibility and regional coordination.

The current system does not enable a clear and effective knowledge sharing mechanism; therefore changes are desirable to implement a network approach and must include coincidence of goals, time scale, and monitoring. The Bolivian law 2878/2004, recognising indigenous *usos y costumbres* for water rights and management, create a window of opportunity to integrate not only different knowledge but to realise through hybrid pathways based on collaboration and participation a new water governance regime. With reference to this Concilio (2000) highlights that participatory decision-making should be seen as a process of collective exploration of the decision space. Therefore, participation has to be an action oriented process and is described as a search process looking for negotiation opportunities enabling participatory decision-making (Celino and Concilio, 2011). Hence, together with progresses in coordination within levels of government, heightened public exposure of bureaucratic processes is crucial since it can promote the construction of a more transparent water governance (Adhikari and Tarkowski, 2013) favouring information sharing and fostering participation and reducing the room for corruption.

3. Transparency

As shown by the Moroccan case study, transparent mechanisms need to be guaranteed otherwise stakeholders have no clue and familiarity about government processes and thus cannot contribute to governance. Pope (2005) states that guaranteed access to information is the most crucial element in building a successful open society. Indeed, access to information allows

stakeholders to get a sense, develop knowledge, and actively participate in water management. Inhibiting the participation of the local community snaps the governance process at its most relevant phase, when acceptance for difficult decisions could have been gained. However, participation is surely costly and this can be a barrier in the two case studies also because it could affect negatively efficiency. Despite this, solutions to water governance issues found through a discussion are indeed difficult to reject afterwards, because people would discredit their credibility if they refused to back up shared decisions. This would result in a decrease in the number of water conflicts. On the other hand, the lack of participation hampers transparency and knowledge exchange and creates room for corruption and elite pressure. As shown by the Moroccan case study, public participation is enhanced also by (recent) social-political changes in the area, thus trade-offs concerning decisions on allocation of water resources among various sectors as well as user groups are increasing.

4. Lack of tools

In the Bolivian case study, where the laws in force attributes the responsibility of water services and the management of micro-irrigation infrastructures to local governments. However, the process of decentralization in the Municipality of Tomave is held back because the Municipality has not developed or lack the needed competences, as well as the required financial and human resources, to carry out the new assigned tasks.

In the Moroccan case study, the capacity gap refers on the one hand to the insufficient scientific and technical capacity related to spotting, filling gaps in the data and making management decision on the base of such data. Such lack of human, scientific, and technical resources highlights the need to strengthen collaboration with donors, NGOs, and Universities. Furthermore, new strategies and feasible pathways should be explored to guarantee an economic resilience and sustainability in both of case studies.

5. Legitimacy

The limited possibility of local water organisations and of other stakeholders to give feedbacks regarding the current and future policies issued in the Draa basin is, coupled with the high level of corruption, one of the primary source of the lack of legitimacy.

The Souss-Massa Draa Basin Agency as well as the other organisations involved will have to face a further problem of legitimacy when they will decide to tackle in a more effective manner the issue of illegal water pumping since, as suggested by Cosen and Williams (2012), how human behaviour does not change just because science indicates it is the right thing to do. Acceptance of choices, whether reinforced by science or not, requires a strong legitimacy of institutions making and executing those decisions.

6. Corruption and Elite pressure

Among barriers, corruption (and in some way elite pressure) presents different features if compared with the other factors. With reference to the two case studies, corruption can be considered indeed a product and a producer of the other barriers since fragmentation as well as the absence of transparency, public participation, and legitimacy in governance creates a fertile context for corruption. Corruption as stated by Banda (2002) can be identified as an emerging threat to equitable and sustainable development. Corruption and elite pressure are a widespread phenomenon in the two case studies (as well as in many other countries), and thus more attention should be put on it, as it threatens efficient water governance and by association, water allocation. Even though more research should be carried out regarding the impacts of corruption in the water field in the two countries, it is possible to state here that in order to suppress this phenomenon actions are required at both the policy and (formal and informal) institutional tiers. Moreover, it must be recognized that reforms will time and considerable political will is needed to implement them.

As shown by the Moroccan case, many of the important decisions about drought/flood risks and climate change are taken at the basin level but power

relations with other levels of authority frequently affect those choices. For instance, with reference to (national) infrastructure planning in Morocco, elite pressure and scale issues are barriers to learning from past interventions. The information collected in the interviews suggests that if local consultations had been undertaken, the problems that the new dams has created could at least have been reduced.

8.4 Ideas for Future research

This dissertation attempts to make theoretical, methodological, and practical advancements that are hopefully useful to policy makers, drought planners, water managers, and resilience and sustainability researchers. Here, I make recommendations to researchers, organisational managers, and decision makers based on my findings.

First, assessing organisational adaptive capacity is not an easy task. Furthermore, since I did not develop a method to measures adaptive capacity, one challenge out-coming from this thesis concerns the construction of a gauging system to evaluate adaptive capacity. Insights on how to develop such measuring scale might come from public organisation and health domains.

Besides, as it has been noted carrying out the literature review and the various interviews in the two case studies, the different capacities related to the organisational adaptive capacity are interlinked and influence, at different levels, each other. Therefore, one such improvement would be to invest more in-depth correlations among the different attributes of adaptive capacity considered in the developed framework in order to better understand synergies and trade-offs identified along the problem management process. The exploration of such correlation, such as leadership and “shadow spaces” (Pelling, 2007), and continuous access to information and leadership, might provide new ideas on how to operationalize organisational adaptive capacities and in identifying barriers within the same organisation, which not enable to developed adaptive capacity.

While the developed framework proves to be a valuable tool for increasing the

robustness of my findings, I suggest that future research should attempt to improve upon and expand the “Process”-“Capacities” analysis as demonstrated in this dissertation. For example, researchers or consultant investigators might consider applying it to focus groups within a (public or private) organisation (e.g. technicians, team and department managers, etc.) gathering data with it from multiple interviews in the same organization, and changing the time periods of inquiry.

Despite the critics the adaptive water management has received, this dissertation tries to better understand how to enable a process of change within water organisations to implement an adaptive water management. *Numerous arguments lead to the conclusion that adaptive and integrated water management is essential in order to guarantee a sustainable management of the world’s water resources. Therefore, it is important not to focus on developing and analysing models for an optimal integrated and adaptive water management regime, but to focus on how to initiate processes of change to get there (Pahl-Wostl, 2008).*

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ANNEX 1: COMBINATIONS OF RESEARCH TERMS AND THE BOOLEAN OPERATOR AND IN FRENCH AND SPANISH

ET	Sécheresse	Terre ferme	Eau	Gestion de la sécheresse	Gestion adaptative	Gestion adaptative	Gouvernance de l'eau	Institutions de l'eau	Capacité d'adaptation de l'institution
Sécheresse	✗	✓	✗	✓	✓	✓	✓	✓	✓
Terre ferme	✓	✗	✗	✓	✓	✗	✗	✓	✗
Eau	✗	✗	✗	✗	✗	✓	✗	✗	✗
Gestion de la sécheresse	✓	✓	✗	✗	✓	✓	✗	✓	✓
Capacité d'adaptation	✓	✓	✗	✓	✗	✓	✓	✓	✓
Gestion adaptative	✓	✗	✓	✓	✓	✗	✓	✓	✓
Gouvernance de l'eau	✓	✗	✗	✓	✓	✓	✗	✓	✓
Institutions de l'eau	✓	✓	✗	✓	✓	✓	✓	✗	✓
Capacité d'adaptation de l'institution	✓	✓	✗	✓	✓	✓	✓	✓	✗

Table i: Combinations of research terms and the Boolean operator AND in French

Y	Sequia	Tierras secas	Agua	Gestión de la sequia	Capacidad de Adaptación	Gestión Adaptativa	Gestión del agua	Instituciones de Agua	Capacidad de adaptación de la institución
Sequia	✗	✓	✗	✓	✓	✓	✓	✓	✓
Tierras secas	✓	✗	✗	✓	✓	✗	✗	✓	✗
Agua	✗	✗	✗	✗	✗	✓	✗	✗	✗
Gestión de la sequia	✓	✓	✗	✗	✓	✓	✗	✓	✓
Capacidad de Adaptación	✓	✓	✗	✓	✗	✓	✓	✓	✓
Gestión Adaptativa	✓	✗	✓	✓	✓	✗	✓	✓	✓
Gestión del agua	✓	✗	✗	✓	✓	✓	✗	✓	✓
Instituciones de Agua	✓	✓	✗	✓	✓	✓	✓	✗	✓
Capacidad de adaptación de la institución	✓	✓	✗	✓	✓	✓	✓	✓	✗

Table ii: Combinations of research terms and the Boolean operator AND in Spanish

ANNEX 2: THE QUESTIONNAIRE (ENGLISH VERSION)

QUESTIONNAIRE

Notes:

All questions scored from 1-5 :

- For 'how effective' questions, 1 = not effective, 5 = very effective
- For 'to what extent' questions, 1 = never, 5 = routinely

1. Overall

- Name of the institution:

- Role of the interviewed within the institution:

How effective is your institution at addressing future problems before they emerge?

How effective is your institution at addressing unexpected problems when they emerge?

2. Identifying a problem

To what extent does your institution seek to understand future trends in your area of work?

1 2 3 4 5

To what extent is your institution able to access data and information related to future trends?

1 2 3 4 5

How effective is your institution at identifying gaps in available data and information? How effective is your institution at filling those identified gaps?

1 2 3 4 5

How effective is your institution at recognising early signs of emerging problems and identifying unexpected problems as they emerge?

1 2 3 4 5

How effective is your institution at identifying future problems before they emerge?

1 2 3 4 5

3. Defining and scoping a problem

Once a problem has been identified, to what extent does your institution communicate internally when defining and scoping the problem?

1 2 3 4 5

To what extent does your institution communicate with other institutions in the organisation when defining and scoping a problem?

1 2 3 4 5

To what extent does your institution seek to bring in perspectives from outside the organisation when defining and scoping a problem?

1 2 3 4 5

How effective is your institution at developing an agreed or shared understanding of a particular problem (i.e. an understanding that reflects the variety of perspectives)?

1 2 3 4 5

To what extent does your institution seek information about past experiences of the organisation when defining and scoping a problem?

1 2 3 4 5

4. Evaluating solutions to a problem

How effective is your institution at taking a proactive approach to dealing with future (anticipated) problems, before they emerge?

1 2 3 4 5

To what extent does your institution communicate with other institutions in the organisation when formulating potential solutions to a problem?

1 2 3 4 5

To what extent does your institution seek to bring in perspectives from outside the organisation when formulating potential solutions to a problem?

1 2 3 4 5

To what extent does your institution seek information about past experiences of the organisation when formulating potential solutions to a problem?

1 2 3 4 5

When formulating potential solutions to a problem, to what extent does your institution stick to well-known, 'tried and true' measures?

1 2 3 4 5

To what extent does your institution experiment with new and innovative solutions?

1 2 3 4 5

To what extent does your institution favour reversible measures over irreversible ones?

1 2 3 4 5

To what extent does your institution see a problem as an opportunity for creative thinking and innovation?

1 2 3 4 5

How effective is your institution at developing clear, actionable solutions to a problem?

1 2 3 4 5

How effective is your institution at developing and selecting solutions even in the face of uncertainty or incomplete information?

1 2 3 4 5

5. Implementing solutions

When implementing solutions, to what extent does your institution moni impacts/effectiveness of those solutions in the short-term? In the long (different response scales)

1 2 3 4 5

To what extent are the monitoring results (positive or negative) commu within the institution? Within the institution? Outside the institution?

1 2 3 4 5

If a solution is seen to be not working, to what extent does your institution adj solution and/or its implementation?

1 2 3 4 5

To what extent are the established processes of finding, defining and problems revised in light of new experiences and/or new information?

1 2 3 4 5

6. General comments