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GOVERNING WATER AND ENVIRONMENT IN TIMES OF CLIMATE CHANGE

THE CASE OF THE VENICE LAGOON

Tesi di dottorato di
STEFANIA MUNARETTO
matricola 955405

Coordinatore del dottorato:

Prof. GIAN MARIA ZUPPI

Tutore e Cotutori del dottorando:

Prof. DOMENICO PATASSINI

Prof. FRANCESCO INDOVINA

Prof. PIER VELLINGA

To my journey

May I always be able to
Become aware
Accept
Transform

Acknowledgments

This PhD has been a journey for me. A journey that brought into my life new wonderful people and made me appreciate even more people who were already in my life.

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Abstract

Climate change is an additional challenge that coastal regions have to face nowadays. To address old and new problems, institutional reforms are increasingly required.

This research focuses on a case study, namely the Venice lagoon. The objective is to explore institutional arrangements for water and environmental management that would improve effectiveness in the governance of the Venice lagoon under conditions of climate change.

For this purpose, a qualitative analysis of scientific literature, archive data and interviews is conducted in three separated studies. In addition to that, knowledge about the functioning of the formal and informal institutional system at work in the studied area was gained during the past six years working in the field of the safeguarding of Venice and was helpful to perform the analysis and interpreting the findings.

The first study reflects on the ability of the non-structural and structural measures for flood protection in Venice to anticipate expected sea-level rise induced by climate change. Then, the second study looks into the institutions for water and environmental management to assess whether they support adaptive capacity of society to climate change. This analysis is done in comparison with another coastal region, the Dutch Wadden Sea with the aim of searching for lessons to be learnt. Finally, the level of implementation of the adaptive co-management as normative framework for effective governance and its implication in terms of policy learning are explored in the third study.

The findings of this research suggest that decades of studies funded by the Special Law for Venice generated technical and scientific knowledge and allowed building infrastructure that could make Venice one of the foremost regions adapting to climate change and an example for other coastal regions to learn. This provided that the governance structure allows for timely completion of all infrastructures as well as adequate management and maintenance by supplying adequate funding and reforming institutions. Reforming the current Special Law for Venice offers an opportunity to develop a novel governance regime with all relevant parties. Taking a climate change perspective in developing the new regime would then ensure long term protection from climate related risks. Recommendations include a possible path and a number of institutions to improve effectiveness in the governance of the Venice lagoon.

1 Introduction

1.1 Background

1.1.1 Climate change in coastal regions

Ecological, economic and social functions of coastal regions will be increasingly difficult to be maintained in the near future because of the impacts of climate change (IPCC 1990a, 2007a; EEA 2005; EC 2009a, b). Coastal systems are especially vulnerable to climate change, according to the Intergovernmental Panel on Climate Change (2007b). Some of the expected impacts include: an accelerated rise in sea level, which may lead to coastal flooding and inundation, erosion and ecosystem losses; a rise in sea temperature with an effect on ecosystems; a change in precipitation and runoff (Nicholls & Tol 2006; IPCC 2007a). These impacts are expected to become more severe in the coming two to three decades as result of accelerated sea-level rise caused by greenhouse gasses that were released in the period between 20 and 100 years ago (IPCC 2007a). The effect in terms of sea-level rise of present days (insufficient) mitigation, then, will be felt about 20 to 50 years from now. As consequence of expected sea-level rise, the availability of low laying coastal land and its uses will be increasingly challenged and the competition for natural resources and environmental services at the coast will be further exacerbated in the near future (EEA 2005; IPCC 2007a; EC 2009a, b).

To reduce risks for human society and losses of coastal assets, adaptation measures can be implemented in coastal regions (IPCC 1990b). Adaptation takes place through adjustments to reduce *vulnerability* or enhance *resilience* and *adaptive capacity* in response to observed or expected changes in climate (IPCC 2007b). It occurs in physical, ecological and human systems and it involves changes in social and environmental processes. Vulnerability and adaptive capacity have specific meanings in the context of climate change, whereas resilience is a concept borrowed from the ecology science. The Intergovernmental Panel on climate change (IPCC 2007b pp. 76-89) defines vulnerability and adaptive capacity as follow.

- Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of

climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

- Adaptive capacity is the whole of capabilities, resources and institutions of a country or region to implement effective adaptation measures. It represents the ability of human society to respond to climate change impacts. It varies between countries depending on social structure, culture, economic capacity, geography and level of environmental degradation.

The ecology science defines resilience as the ability of an ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt naturally to stress and change (Holling 1973; Peterson et al. 1998; Gunderson 2000; Carpenter et al. 2001). In recent times, this concept has been given special meanings in the domain of coupled human-environment systems with important consequences for natural resources management. In particular, an interdisciplinary group of scientists launched the Resilience Alliance network which has developed a framework for understanding changes in social-ecological systems that includes the notions of resilience, adaptive capacity, adaptive management and adaptive governance (Berkes & Folke 1998; Ostrom 1999; Adger 2000; Folke et al. 2002, 2005; Olsson et al. 2004, 2006; Lebel et al. 2006).

Vulnerability, adaptive capacity and resilience are interrelated concepts in the climate change domain. Vulnerability depends on the adaptive capacity and on the level of resilience embedded in social and ecological systems (Brooks 2003; Adger 2006; Smit & Wandel 2006; Miller et al. 2010). Resilience and adaptive capacity, then, are similar concepts in the sense that both refer to the ability of human and natural systems to cope with change. Adaptive capacity refers to a proactive approach taken by humans to respond to change forced by human induced global warming. Resilience refers to the ability of social and natural systems to maintain their structure and functioning properties under all sort of disturbances, including climate change. Resilience involves the concept of threshold, i.e. the level of disturbance that the human or natural system is able to absorb without changing state (i.e. structure and properties). Applied to social structures (i.e. institutions) resilience is often considered a synonym of adaptive capacity (IPCC 2007a). In the past decade, characteristics, drivers and barriers to improved adaptive capacity and resilience and reduced vulnerability have been explored by a high number of scientists in an attempt to build conceptual frameworks for

effective adaptation (Vellinga & Klein 1993; Smithers & Smit 1997; Klein & Maciver 1999; Smit et al. 1999; Wheaton & Maciver 1999; EEA 2005; Füssel 2007; Quay 2010).

Adaptation practices can be classified in several ways (IPCC 2007a). According to the type of action, adaptation may include technological and engineering options (e.g. sea defenses), management of natural resources, land use change options, policy intervention, organizational change options, and planning regulations (Smithers & Smit 1997; Klein & Nicholls 1998; IPCC 2007a; EC 2009a). In general, a balanced mix of structural (i.e. technological and engineering) and non-structural (i.e. managerial, policy, organizational and planning) measures is recommended to increase adaptive capacity and resilience of social and ecological systems (Smith & Lenhart 1996; Smit et al. 1999; Wheaton & Maciver 1999; Kundzewicz 2002; Kabat et al. 2005; Smit & Wandel 2006).

Adaptation in the coastal zone has often been defined also in terms of protection, accommodation, and retreat options (IPCC 1990b; Feenstra et al. 1998; Klein & Nicholls 1998; Klein et al. 2001; Kay & Alder 2005; Nicholls & Klein 2005). Protection means preventing impacts from being experienced. Hard and soft sea and river defenses are typical coastal protection measures in the case of flooding and erosion. Accommodation entails reducing vulnerability to climate change impacts. Typical accommodation measures to cope with regular inundation in coastal regions are extensive elevation of property, modification of urban drainage systems and raising of roads. Retreat implies major land use changes. These include shifting homes and other infrastructure away from vulnerable positions, acquisition of land and property by public authorities to create buffer zones, planning set-back zones or subsidies to coastal inhabitants to relocate inland. In some coastal regions, only protection and to some extent accommodation is possible, whereas retreat is not an option because of the high historical, cultural and/or socio-economic value of the region. This is the case, for example, of historical cities at the coast such as the city of Venice in Italy.

1.1.2 Environmental governance

Governance has become a key concept in policy research to respond to the inherent uncertainties in human and natural systems (Ostrom 1990; Rhodes 1997; Van Kersbergen & Van Waarden 2004; Armitage et al. 2007; Kallis et al. 2009). The concept is not uniformly defined in the social science literature (Van Kersbergen & Van

Waarden 2004; Biermann et al. 2010). According to Rhodes (1996) there are at list six separate uses of governance: as the minimal state; as corporate governance; as the new public management (Hood 1991; Pollitt 1993); as "good governance" (World Bank 1992); as socio-cybernetic system (Kooiman 1993); as self-organizing networks. Conversely, the literature seems converging on what governance is not: it is not a synonymous for government. Rather governance signifies a change in the meaning of government (Rhodes 1996). One of the main characteristics of governance is, in fact, the transition from traditional government (bureaucratic, centralized top-down steering) to new forms of horizontal and vertical decision-making that are less hierarchical and more inclusive, decentralized and flexible (Biermann et al. 2010). The involvement of private actors and citizens in public decision-making is of major importance in governance processes.

Governance in the context of the management of the environment is known as *environmental governance*. According to a wide and rather well established stream of literature environmental governance encompasses the whole of formal and informal institutions that shape human-environment interactions at all levels of social organization (Ostrom 1999; Adger et al. 2003; Dietz et al. 2003; Paavola 2007; Kallis et al. 2009; Biermann et al. 2010). Institutions, then, are the "systems of rules, decision-making procedures, and programs that give rise to social practices, assign roles to the participants in these practices, and guide interactions among the occupants of the relevant roles" (IDGEC 1999 p. 14). Environmental governance research addresses environmental policies and management practices, common property resource regimes, collaborative decision-making processes, and markets for environmental goods and services. Object of study are institutional arrangements as well as issues of authority, accountability, legitimacy, participation, and fairness and equity.

As result of global environmental change modern societies are confronted with surprise, unpredictability, and the possibility of unexpected 'tipping points' in the management of the environment (Dietz et al. 2003; Olsson et al. 2004; Folke et al. 2005; Armitage et al. 2007). Furthermore, policy decisions regarding natural resources and environmental services are increasingly less a matter of appropriate expertise or the domain of specialist institutions, and more a question of negotiation and agreement among stakeholders (Brunner et al. 2005). To address these challenges major institutional reforms are required in modern environmental governance systems (Young 2007). This is a challenging task because institutions are traditionally conservative (Gupta et al.

2010) and inherently not tailored for allowing to make timing decisions, which is a priority in a world of increasing uncertainty and risk.

Within the vast governance literature, the *adaptive governance* approach has been developed as framework to address the evolution of institutions in the context of change. Born within the institutional theory, the adaptive governance framework combines ecological concepts applied to natural resources management (Gunderson & Holling 2002) with the studies on the management of common pool resources and self-organizing communities carried out by Elenoir Ostrom (1990, 1999). Initial studies focused on a framework for natural resources management based on learning by doing or implementing policies as experiments, the so called *adaptive management* (Holling 1978; Walters 1986; Schreiber et al. 2004; Kallis et al. 2009). Later on, the theoretical foundation has expanded to the dynamics of complex systems which has led to the definition of coupled, interdependent social-ecological systems and to the new concept of *co-management* (Berkes et al. 1991; Wondolleck & Yaffee 2000; Carlsson & Berkes 2005). By emphasizing the role of collaboration among actors in common resources management, this new conceptualization shifts the focus from improving technical practices and routines by experimenting and learning (typical of the adaptive management approach) to the role of institutions, social capital, networks and coalitions of actors. In more recent times, the governance literature on adaptive management and that on co-management have been converging into a literature on *adaptive co-management* (Olsson et al. 2004; Plummer & Armitage 2006; Armitage et al. 2007, 2009). On the one hand, adaptive management emphasizes learning and uses structured experimentation in combination with flexibility as ways to achieve it. On the other hand, co-management emphasizes the sharing of rights, responsibilities, and power between different levels and sectors of government and civil society. Adaptive co-management, then, is a novel combination of the learning dimension of adaptive management and the linkage dimension of co-management (Olsson et al. 2004; Armitage et al. 2007).

Over the years principles and criteria for effective governance of environmental resources have been developed by adaptive governance scholars (Ostrom 1990, 1999, 2007; Dietz et al. 2003; Olsson et al. 2004, 2006; Folke et al. 2005). Empirical research, then, has proved the adaptive governance approach to be successful in a number of small local communities (Ostrom 1990). However, when the complexity of the system increases and problems need to be dealt with at both global and local level (such as in

the case of climate change), solutions are not that straightforward. Lee (1999 p. 5), for example, suggested a while ago that the adaptive management "has been much more influential as an idea than as a way of doing conservation so far." Adaptive co-management, then, is attractive as an idea but very hard to introduce and sustain in practice. Different responses to this conclusion, which still holds, are possible. One is to submit adaptive co-management as a Weberian "ideal type", declaring it only a hypothetical concept in the abstract and a subjective notion which might inspire practice but will never be fully realized. Another is more empirical; this would entail questions about what holds back the introduction of adaptive co-management in real life settings, but also an assessment of the consequences of non-implementation. In this vein of reasoning, Armitage et al. (2007 pp. 6-10) recently pointed to the need for more insight on enabling policy environments and "conditions of adaptive co-management success and failure". One way to empirically learn more about enabling environments for adaptive co-management is to focus on case studies where the concept of adaptive co-management potentially has much added value but is not fully applied, or not fully applied yet.

1.2 The case study of this research

The case study of this research is the Venice lagoon (also referred as Venice system in the text). In particular, the research focuses on the institutional arrangements for water and environmental management at work in this region. The following paragraphs briefly describe the social and ecological system, point out possible impacts of climate change and illustrate the governance arrangements for water and environmental management existing in the region. Further description of the Venice system can be found in chapter 2, 3 and 4. The last paragraph of this section (prf. 1.2.5) explains the need to reconsider the current environmental governance system in the Venice lagoon.

1.2.1 Physical and ecological system

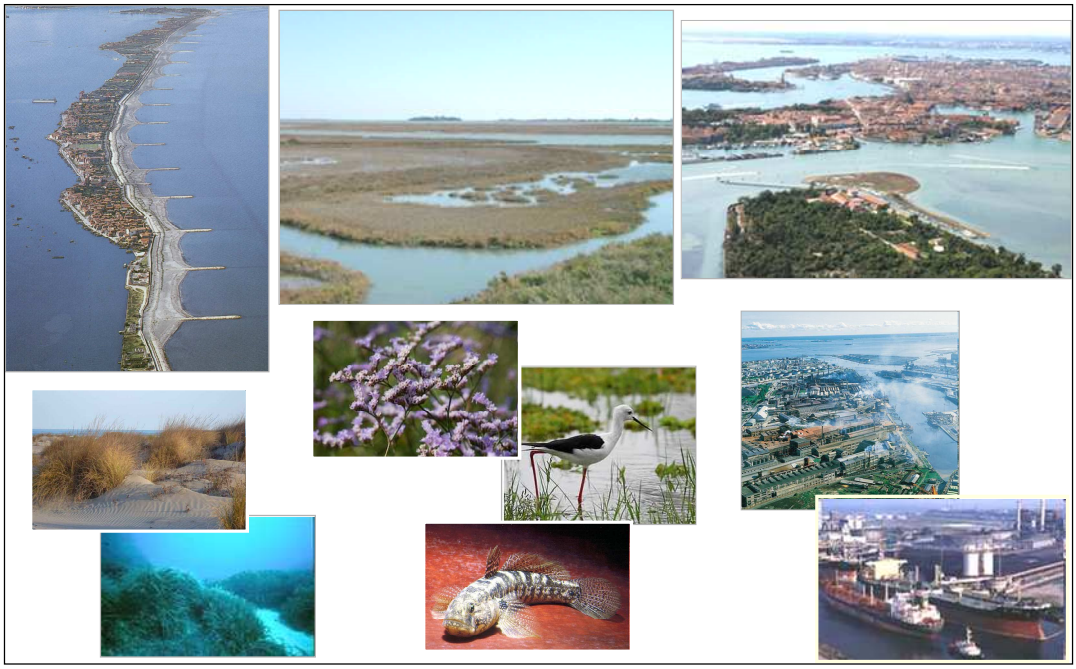
Located in North-East Italy, the Venice lagoon is the largest coastal lagoon of the Mediterranean region. It is a shallow water basin (on average one meter deep) that covers 550 km^2, most of which opened to sea tides through three inlets (see Figure 1.1). About 60 km of sand strips design the lagoon coast line.

Figure 1.1 The Venice lagoon

Source: Venice Water Authority

Typical coastal environments (dunes, beaches), wetland habitats (salt marshes, mudflats and shallows), and brackish and fresh water environments (reeds) constitute a rich and diversified ecosystem evolved over more than six thousand years (Torricelli et al. 1997; Ravera 2000). The whole basin is cut by a dense network of natural (tidal driven) and artificial channels ranging from 15 to 1-2 meter depth through which tides spread into the lagoon. Islands, reclaimed land and banks represent about eight per cent of the lagoon surface. At the heart of the lagoon, there is the historical city of Venice which, with the lagoon, has been a UNESCO World Heritage site since 1987 (see Figure 1.2).

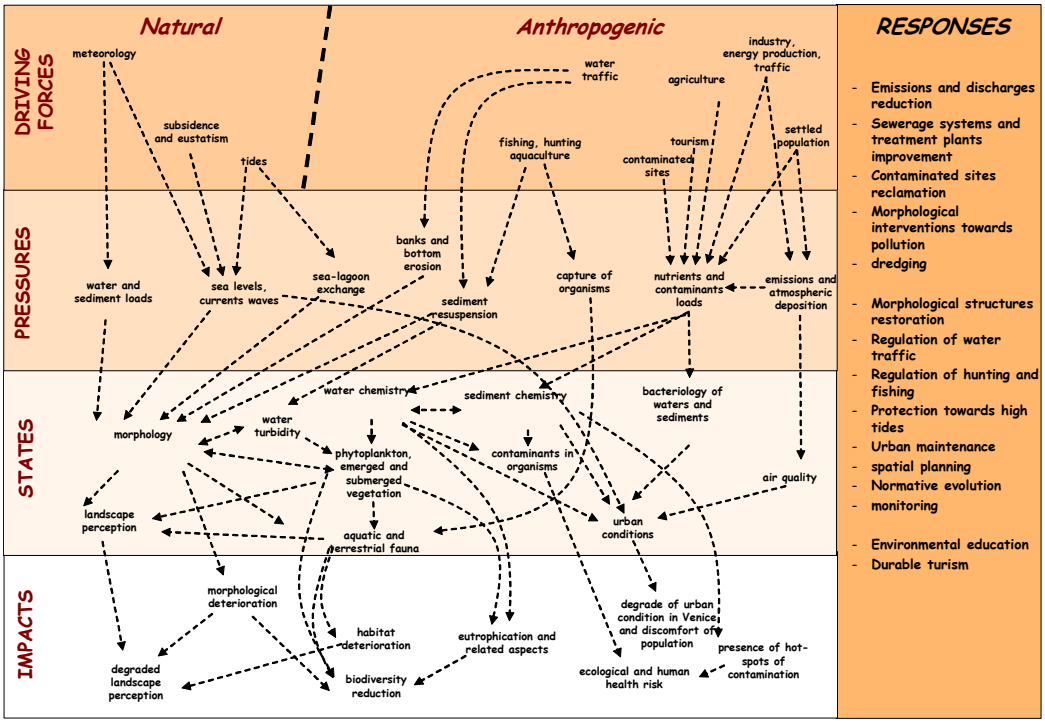
Figure 1.2 The physical environment in the Venice lagoon



Source: various internet websites

Venice and its lagoon is a complex and vulnerable artificially conserved natural system which has been shaped by the interaction of humans and natural dynamics for centuries (Bevilacqua 1998; Lasserre & Marzollo 2000; IVSLA 2000; Ramieri 2000; Ravera 2000; Musu 2001a; Bonometto 2005; Mag.Acque-Thetis 2006a; Rinaldo 2009; OECD 2010; Solidoro et al. 2010). Similarly, to many other coastal regions, the sustainable management of natural resources and ecosystem services is challenged by multi-actors over-use. In Figure 1.3 a conceptual framework according to the DPSIR model (Mag.Acque-Thetis 2006b) explains the links among the different components of the system. A number of natural and anthropogenic drivers cause coastal erosion, morphological degradation, loss of habitat and biodiversity, water, sediment and land contamination, and urban degradation. Natural drivers are mostly tides, subsidence, eustacy and meteorological factors (winds, precipitation, storm surges). Human drivers are associated with the economic activities in the lagoon and in the catchment basin (industry, fishery, commercial and industrial port, agriculture and tourism) and the interventions into the lagoon basin to maintain its capacity to support those activities (e.g. changes of the lagoon morphology, dredging of shipping channels, etc.).

Figure 1.3 Conceptual model for the Venice lagoon ecosystem according to the DPSIR model



Source: (Mag.Acque-Thetis 2006b)

Erosion and water level variations are the two major threats for the existence of the lagoon and of its historical urban centers (Harleman; Rusconi et al. 1993; Sorokin 1996; Gornitz et al. 2000; Nosengo 2003; Solidoro et al. 2010). These are also the dimensions that climate change and sea level rise are likely to affect the most in the coming decades.

The Venice lagoon physical existence depends on the balance existing between sediments accumulation in morphological structures and erosion, which is related to fresh water inflow and sea water exchange. Whereas in the first half of the last millennium a natural tendency towards the accumulation of solid material was turning the lagoon to dry land, the diversion of river tributaries (Brenta, Sile, Piave and Bacchiglione) carried out between 1500 and 1860 and works to allow big vessels to reach the port constructed between 1840 and 1930 (i.e. construction of jetties at the inlets, dredging of deep shipping channels and deepening of the inlets) triggered erosive processes. In addition, since the 1990s the techniques used for the commercial harvesting of the non native clam species *Tapes Philippinarum* has become a new source of erosion[1]. To date, the overall balance of sediments is negative with the erosive

[1] The clam harvesting tools plough the lagoon beds causing suspension of sediment and damaging the sea grass meadow.

action of wave motion and coastal currents being the prevailing forces (Rinaldo 1997; Mag.Acque-Thetis 2006a). This is turning the lagoon into a marine environment.

The main evidence of erosion is the progressive flattening of the lagoon basin with relative deepening of shallow water, disappearance of salt marshes and filling up of the shipping channels. Of the 90 km^2 salt marshes covering the lagoon basin at the beginning of the 20^{th} century, 70% has been lost, remaining only 8% of the lagoon surface covered by these intertidal areas at present time (Rinaldo 1997; Day et al. 1999; Ramieri 2000; Bonometto 2005; Mag.Acque-Thetis 2006a; Marani et al. 2007).

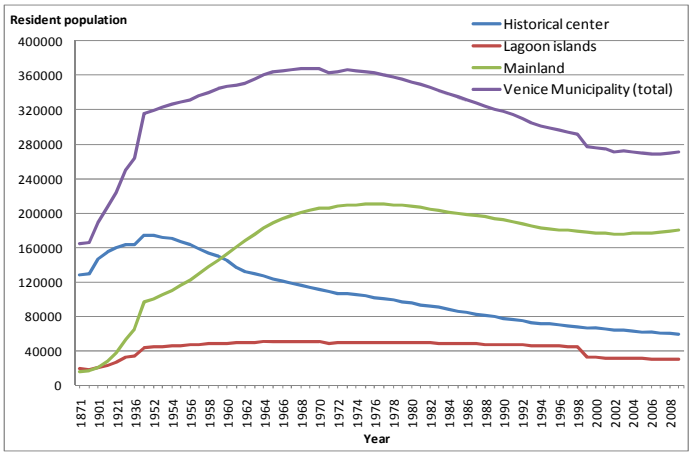
The city of Venice has experienced high variations of lagoon water level for centuries (Rusconi et al. 1993; Rinaldo 1997; Canestrelli et al. 2001; Pirazzoli & Tomasin 2002; Mag.Acque-Thetis 2006a; Ferla et al. 2007; Plag 2008; Carbognin et al. 2009). The phenomenon, known as high water[2] (locally called *acqua alta*), consists of a temporary rise in the sea level that floods part of the city and the other lagoon settlements for a few hours. It may occur several times a year, particularly in winter, causing degradation of urban buildings and damages to the economic activities. The frequency of high water events has increased in Venice over the last hundred years because of eustacy and natural and human-induced subsidence. While at the beginning of the last century exceptional high water events used to occur on average 1-two times a year, since middle 1990s they have rapidly increased, reaching 15 episodes in the 2009. Extreme high waters have also become more frequent: four events occurred only in December 2009.

1.2.2 Population and economy

A structural change in the economy and in the society of the Venice region has been going on for several decades. Since the second half of the twentieth century the population of the historical centre of Venice and of the islands has been declining and aging (Musu 2003; Vellinga & Lasage 2005; Da Mosto 2009; see Figure 1.4). In the year 2009 the population of the historical center has reached the critical threshold of 60,000 inhabitants down from 170,000 in 1950s. Other 30,000 people live in the islands. Together with the mainland cities of Mestre and Marghera, the Venice municipality counted 270,800 inhabitants in the year 2009 (Venice Municipality 2010).

[2] High water is defined as a tide exceeding 80 cm respect to the conventional zero which is the average sea level measured at Punta della Salute station in Venice in 1897 (mean sea level – m.s.l.). 80 cm m.s.l. represents the water level that start causing floods in the lower parts of the historical town. Exceptional high water is a tide exceeding 110 cm m.s.l. that floods more than 10% of Venice while extreme high water is a tide exceeding 140 cm l.m.m., which causes 90% of the city to be flooded.

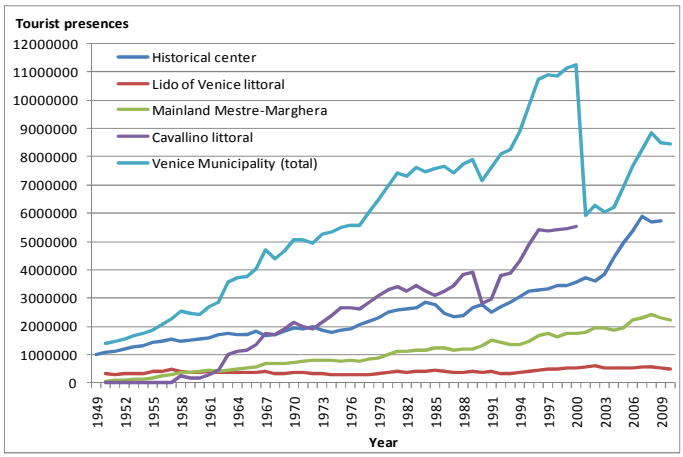
Figure 1.4 Population dynamic in the Venice municipality for the period 1871-2009



Source: data from Servizio Statistica e Ricerca - Comune di Venezia

Tourism, recreation and related activities are the most important economic resources of the Venice area (van der Borg & Russo 2001; Musu 2003; Vellinga & Lasage 2005; Da Mosto 2009). More than 8.5 million tourist presences have been registered in hotel and non-hotel accommodations in the year 2009 in the Venice municipality, of which about 6 million only in the historical city center of Venice (Venice Municipality 2010; see Figure 1.5). Including the high number of excursionists, the tourist presences raise up to about 24 million.

Figure 1.5 Tourist presences in hotel and non-hotel accommodations in the period 1949-2009



The drop in the total amount (corresponding to the interruption of the line referring to the Cavallino littoral) is due to the fact that Cavallino become a separated municipality from Venice in 2002, and consequently the Venice municipality does not have data referring to Cavallino since that time)

Source: data from Servizio Statistica e Ricerca - Comune di Venezia

The production of petrochemical products in Porto Marghera (one of the largest industrial areas in Italy) has been declining since the late 1970s and now has no longer a

leading role in the economic development of the Venice region. At present a vast national program for pollution remediation is undergoing in the whole area and the near-shore lagoon waters (i.e. Master Plan per la Bonifica dei Siti Inquinati di Porto Marghera, 2004). Possible future uses of the 2,000 ha of industrial land (partially still used) is as logistic to support the port activities. The commercial port is, in fact, increasing transportation of containers and the tourist port is expanding the cruises. These two sectors and the related logistic are expected to take over most of the employees of the industrial area and to reduce the local unemployment.

Fish farming and open sea fishing were important sources of income in the past. In the mid 80s, to boost the declining fishing sector, the clam species *Tapas Philippinarum* was introduced in the lagoon and soon became an important source of income (Provincia di Venezia 2009; Solidoro et al. 2010). As it causes erosion and habitat degradation, clam harvesting has been regulated since 1999. Free clam harvesting in the lagoon is not allowed anymore, and clam farms have been established. However, illegal clam harvesting is difficult to eradicate.

Agriculture is limited to a few islands in the lagoon, whereas is prevailing in the mainland and in the catchment basin, along with medium-small manufacturing firms.

1.2.3 Expected impacts of climate change

Climate change is likely to exacerbate existing problems in the Venice lagoon, threatening its existence (Sestini 1992; Cecconi 1996, 1997; Mag.Acque-CVN 1997; Collegio di Esperti di Livello Internazionale 1998; Ramieri 2000; Mag.Acque-Thetis 2006a). The expected major impact is the increase in frequency, distribution and elevation of high water events due to sea level rise. The increased action of waves and salt water due to more frequent high water events would accelerate urban degradation by damaging building foundations, canal banks, catchment systems and lagoon embankments. Temporary interruption of economic activities, damages to good stored in shops and warehouses and interruption of mobility would cause loss of economic assets and increase of citizen discomfort (Cecconi 1997; Canestrelli et al. 1998; Collegio di Esperti di Livello Internazionale 1998; Carraro & Nunes 2004; Breil et al. 2005; Vergano & Nunes 2007).

The most likely impacts on the lagoon ecosystems are increased erosion, permanent submersion of low-laying areas, increase of water level, intensification of water

exchange and increase of water salinity and temperature which would accelerate the transformation of the lagoon into a marine environment (Mag.Acque-CVN 1997).

Submersion of low-lying areas both in the lagoon and in the inner territory will cause loss of natural habitats and land for human activities. Greater water depth will increase the mean height of wind generated waves causing intensification of erosion of typical lagoon structures (Mag.Acque-CVN 1997). According to Ramieri (2000) salt marshes could disappear within 30-50 years if present natural and anthropogenic factors responsible for the erosive processes will continue. However, he argues, salt marshes located in the proximity of river mouths might be able to counteract the effects of sea level rise.

Greater water level would lead to reduced oxygenation of deep water, causing alteration of biogeochemical reactions. It would also partially contribute to greater dilution of pollutants and vivification of the lagoon. Furthermore, greater water exchange would increase mean salinity and modify mean lagoon water temperature. Higher water temperature is likely to affect water quality, primary production, biodiversity distribution and composition, and biogeochemical processes (Cossarini et al. 2008), including chemical reaction of contaminants trapped in the lagoon sediment and of those dissolved in the water.

Modification of precipitation patterns is likely to change seasonal water, pollution and sediment load from the catchment basin, making it higher in wintertime and lower in summertime than in present day situation (Mag.Acque-CVN 1997; Cossarini et al. 2008).

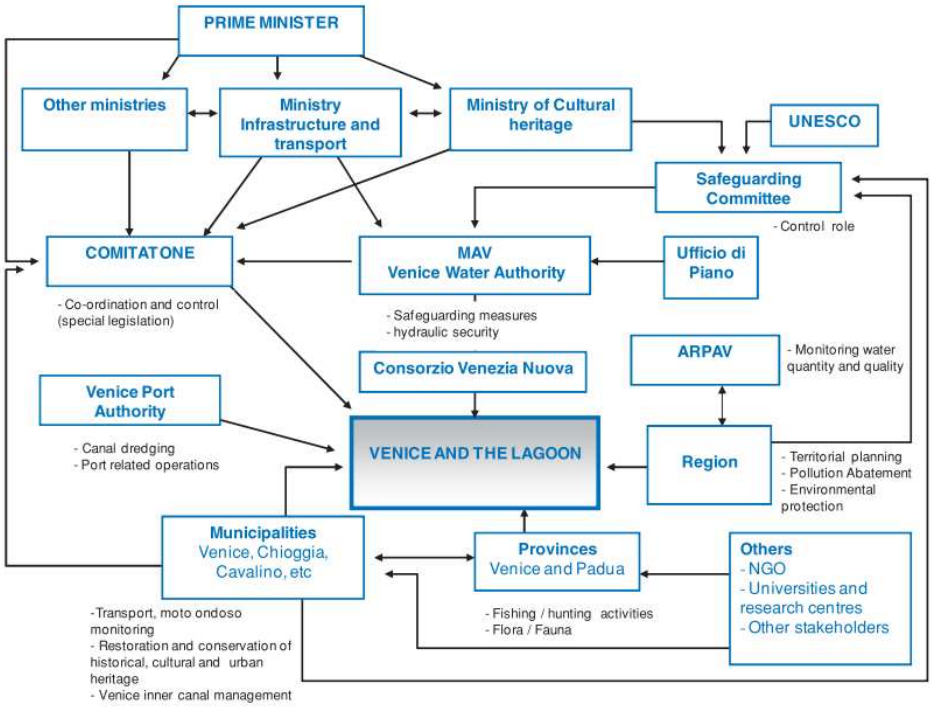
Finally, due to sea level rise intensification of saltwater intrusion into rivers would prevent the use of water for agriculture, could lead to salt accumulation in soil and alter the distribution and abundance of the estuarine communities (Sestini 1992; Ramieri 2000).

1.2.4 Governance arrangements for water and environmental management

The governmental system in Italy is hierarchically structured with four vertical levels of government: state, regions, provinces and municipalities. Regions have autonomous decision power in many government spheres, including water, ecosystems and environmental management. The Venice lagoon is entirely included in the Veneto region.

The governance system of the Venice lagoon is rather complex (Amorosino 1996, 2002; Bevilacqua 1998; Da Mosto 2009; OECD 2010) (see Figure 1.6 and Table 1.4). In addition to a vast ordinary legislation deriving from international, European and national regulations for water and environmental management (illustrated in Table 1.2 and Table 1.3), a framework of national laws and ministerial decrees known as "the Special Law for Venice" has established goals, instruments, and governments' responsibility for the safeguarding of Venice since the early 1970s (see Table 1.1). Within the Special Law regime a number of coastal and flood defense infrastructure are being built. In particular, a system storm surge mobile barriers (known as the MOSE system) is under construction. For details about the Special Law regime and the infrastructure see chapter 2.

Figure 1.6 Organizations responsible for protecting the Venice Lagoon



Source: (Da Mosto 2009)

Table 1.1 Major Special Law and regulations for the safeguarding of the Venice lagoon

Law no. 171 of 16 April 1973 ***Interventions for the safeguarding of Venice***
The safeguarding of Venice and its lagoon is declared of national interest.
The Italian government via the Ministry of Infrastructure and its local agency the Venice Water Authority, the Veneto Region and the municipalities of Venice and Chioggia are in charge of the safeguarding of Venice.
The Italian government is responsible for the physical protection of the Venice lagoon through regulation of tidal levels within the lagoon; the Veneto Region is responsible for identifying the catchment basin and to abate water pollution in it; the Venice and Chioggia municipalities are responsible for restoration and conservative improvement of urban infrastructures and buildings.
Law no. 798 of 29 November 1984 ***New interventions for the safeguarding of Venice***
It establishes the Inter-ministerial Coordinating Committee (*Comitatone*) for the coordination and control of the safeguarding measures and allocation of funds.
It re-affirms and specifies national and local authorities' responsibility.
It sets the safeguarding goals, which are: re-establishing the lagoon's hydro-geological equilibrium; reversing the deterioration process in the lagoon basin and eliminating its causes; protecting the lagoon urban settlements from flooding also by means of interventions at the inlets in the form of mobile barriers for tidal regulation.
It provides funds to support studies, projects, experiments and works to achieve the safeguarding goals.
Law no. 139 of 5 February 1992 ***Inter-institutional agreement of 8 August 1993 among Venice Municipality, Veneto Region and Venice Water Authority***
The law allocates funds to carry out maintenance works of the Venice canals and restoration of buildings foundation facing the city canals.
The agreement establishes procedures and identifies the Venice municipality as responsible authority to carry out the maintenance works in Venice.
Ministry of the Environment, Decree of 23 April 1998
It sets water quality objectives to pursue in the Venice lagoon and in the water bodies in its catchment basin.
It sets characteristics of wastewater treatment plants that discharge in the Venice lagoon and in the water bodies of its catchment basin.
Ministry of the Environment, Decree of 9 February 1999
It sets the total maximum admissible load in the Venice lagoon for a number of pollutants.
Ministry of the Environment, Decree of 30 July 1999
It sets limits to industrial and civil wastewater discharge in the Venice lagoon and in the water bodies of the catchment basin.
Law no. 443 of 21 December 2001 and following implementation acts
It includes the construction of storm surge barrier to protect Venice from flooding (i.e. the MOSE system) in the list of the strategic infrastructure for Italy and it allocates funds to build it.
Protocol of 8 April 1993 among Venice municipality, Veneto Region and Venice Water Authority
It sets criteria and procedures for removal, re-use and disposal of polluted sediment in the lagoon.

In Table 1.2 and Table 1.3 the main international, national and regional institutions for water and environmental management at work in the Venice area are illustrated in terms of their goals, instruments and the level of integration of climate change.

Table 1.2 International institutions at work in the Venice lagoon and their relevance for climate change adaptation

World Heritage Convention
Goal: to encourage the identification, protection and preservation of cultural and natural heritage considered of exceptional value to humanity
Instruments: World Heritage List of sites under the convention; Management plan for each World Heritage site is demanded by 2012
Climate change: a UNESCO study on impacts of climate change on World Heritage (2007) concludes that climate change could irreversibly damage historic cities and settlements and destroy important ecosystems. Taking into account interaction among natural, cultural and social aspects of conservation is considered to be of paramount importance

Table 1.2 continue

Venice

Since 1987 Venice and its lagoon is in the UNESCO World Heritage list. Attention is given to conservation of cultural, historical, artistic and architectural heritage and support to scientific research on the lagoon environment (Sorokin 1996; Lasserre & Marzollo 2000).

Since 2010, the management plan of the Venice lagoon world heritage site is being developed by UNESCO and the Venice municipality. Climate change will be considered in the plan.

Wetlands Convention (Ramsar)

Goal: conservation and wise use of wetlands and their resources through local, regional and national actions and international cooperation

Instruments: list of Wetlands of International Importance; it encourages national land-use planning, appropriate policies and legislation, management actions, public education and international cooperation

Climate change: the Convention does not mention climate change. However, climate change is widely studied by the Ramsar parties which consider it a threat for the existence of global wetlands. Emphasis is also given to the role of wetlands for mitigation and adaptation. In this regard, the convention is an institution that may receive growing attention in the coming years.

Venice

Since the 90s local administrations and stakeholders support the inclusion of the Venice lagoon in the list of the Ramsar sites. Consensus has not been built yet because Ramsar sites in Italy are subjected to the strict nature conservation which limits economic activities in protected areas

EU Natura 2000: Birds and Habitats Directives

Goal: Natura 2000 is the European Ecological Network of protected areas made up of Special Protection Areas for the protection and conservation of wild birds in the EU (birds directive) and Special Areas of Conservation to promote the maintenance of biodiversity through the conservation of natural habitats and wild flora and fauna (habitat directive).

Instruments: management plans and measures are required to be adopted to preserve, maintain or re-establish a sufficient diversity and area of habitats for all the flora and fauna species of all Natura 2000 sites.

Climate change: the two directives do not mention climate change. As an institution, Natura 2000 is very static: species should be protected at the location and in the habitat in which they live now. This is difficult to realize even under 'normal' natural variability, let alone under circumstances in which climate change exacerbates natural variability.

Venice

The whole Venice lagoon, excluding the islands forming the city of Venice and the surrounding waters, is part of Natura 2000 network.

Since 2007, the Veneto Region (in charge of the management of its Natura 2000 sites) and the Venice Water Authority have started to develop the management plan of the Special Protection Area "Venice Lagoon".

Climate change is not explicitly mentioned in the preliminary document for consultations so far elaborated, although it can be identified within the "reduction of the effects of natural drivers" stream of action.

The need to include measures to address climate change impacts on nature is emphasized by the Ufficio di Piano in a recommendation document (2010d) for the elaboration of the Natura 2000 management plan.

EU Water Framework Directive (WFD)

Goal: achieving a "good ecological status" of all inland surface waters, transitional waters, coastal waters and groundwater by the year 2015

Instruments: river basin district as main unit for water management; management authority for each district; management plan for each district establishing environmental objectives, programs of measures and monitoring programs by 2009; implementation of the programs of measures by 2012. Possibility to develop supplementary management measures/plans for sub-basin or specific issues

Climate change: The WFD does not explicitly take climate change into account. However, because the water sector is generally well aware of climate change, it is expected that the directive will remain relevant in the future even under climate change

Venice

The Venice lagoon, its catchment basin and the near-shore sea is a sub-unit of the Alpi Orientali Water District, a large district of about 37,000 km^2 that span in 4 regions and 2 autonomous provinces

The WFD management plan for the Alpi Orientali District was adopted in the early 2010. The water district authority has not been established yet. The existing water boards implement the plan at present

Within the WFD management plan for the Alpi Orientali District, a specific management plan has been elaborated for the sub-unit Venice lagoon, catchment basin and near-shore sea. Climate change is presented as an issue that needs to be further studied to reduce uncertainty. Monitoring of climate parameters and possible impacts is the only action taken so far and foreseen in the near future by the plan

Table 1.2 continue

EU Floods Directive
Goal: assessment and management of flood risk aiming at the reduction of adverse consequences
Instruments: flood risk assessment (by 2011), flood hazard maps (by 2013); flood risk management plans, maps and measures (by 2015); coordination and integration of flood risk management and WFD plans
Climate change: one of the motives behind the Floods Directive is the notion that climate change exacerbates floods. Furthermore, the flood risk management plans should be evaluated and adjusted every six years, "taking into account the likely impacts of climate change on the occurrence of floods"
Venice
In Italy, regions together with regional Civil Defense departments have to adopt measures to implement the directive at the scale of the water district. Specific actions have not been taken yet but measures to deal with risk of flooding already exist at national and regional level
The Veneto Region has developed a regional plan that includes a regional archive of areas at risk of flooding, landslides and avalanches and relative mapping. Climate change is not discussed in this plan
Venetians are familiar with flooding. At the lagoon inlets storm surge barriers are being built to prevent flooding of the lagoon urban areas. The system can withstand +50 cm sea level rise even in case of prolonged closures (Rinaldo et al. 2008). The barriers are considered to be the adaptation response to sea level rise in the Venice lagoon for the next 100 years (CVN 2010).
EU Marine Strategy Directive
Goal: achieving "good environmental status" in the marine environment including coastal waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend
Instruments: establish marine region and sub-region in the EU; develop marine strategy establishing clear environmental objectives and targets (by 2012), cost-effective measures (adopted by 2015 and implemented by 2016) and monitoring programs (by 2015) for each region; coordination and integration of marine strategy and measures with WFD plans
Climate change: the directive recognize that the determination of good environmental status may have to be adapted over time because of the impacts of climate change to the marine ecosystems. Accordingly, programs of measures should be flexible and adaptive and take account of scientific and technological developments
Venice
The directive has not been transposed in the Italian legislation yet
Under the current Italian law for sea protection (law n. 979/1982), there are 24 marine protected areas. Venice lagoon is not one of them.
A national sea and coastal defense plan has not been developed so far. Some regions, however, have adopted their own coastal management programs. The Veneto region has not.
A 300m wide coastal line is identified as natural heritage area undergoing landscape and building restrictions (law n. 431/1985)

Table 1.3 National, regional and local institutions at work in the Venice lagoon and their relevance for climate change adaptation

Nature conservation Law
The Law n. 395 of 1991 establishes 6 typologies of protected areas and 3 levels of protection to be identified for each protected area. According to the level of protection different restrictions to economic uses of the area are applied
In view of climate change, protection of nature from development is positive both for mitigation purposes (i.e. carbon storage) and adaptation (they function as buffer zones for example in coastal areas to protect from flooding).
Governmental authorities are reluctant to set up new protected areas because the law is particularly strict with reference to economic uses of protected areas
Spatial Planning Law
The national Urban Planning Law dates back to 1942. Since the 70s, responsibility for spatial planning was transferred to the regions, although the national law is still in force. To date, each level of vertical administration has its own competences for spatial planning. The structure is hierarchical, meaning that plans of lower order are to comply with requirements of higher order plans. Regional plans give guidelines and restriction of uses. Provincial and municipality plans are more operative. The development of spatial plans at all administrative levels is negotiated with all institutional and non-institutional stakeholders.
Climate change is a more recent issue that the national law does not consider. At regional and local level, discussion about the role of spatial planning to address climate change has recently started. Direct actions do not exist in many regions yet. Measures that indirectly address climate impacts, however, can be identified. For instance, the Veneto Region Spatial Plan (Piano Territoriale Regionale di Coordinamento), which is the highest in the hierarchy of plans, requires local plans to abate pollution, to preserve the landscape and to improve the environmental and hydraulic quality and safety of the Venice lagoon.
Water law on safety, water quality and water management
The Italian water regulation is provided by the Governmental Legislative Decree n. 152 of 3rd April 2006. With regard to water issues, the law addresses hydraulic security of the territory, protection of waters from pollution and management of water resources. It also transposes the WFD directive and establishes water districts according to it.
The law requires regions to develop a Regional Water Protection Plan. The plan coordinates environmental objective with objectives for specific uses of waters and has to comply with water quality objectives identified by the WFD management plans. The plan also identifies measures for quantitative and qualitative protection of water bodies.
Climate change is not explicitly part of the water law, although some regions address climate change impacts on water resources in their Regional Water Protection Plan (see below in this table).
Regional water management and water boards
In the Venice lagoon and surrounding territory there are four different authorities dealing with water management: the Veneto region, the Venice Water Authority, the Alto Adriatico water board and the Consortia for the management of reclaimed land
According to the Law n. 183 of 1989, the water boards are in charge of hydraulic safety both inland and at the coast, water management (both quality and quantity), maintenance of hydraulic infrastructure. Each water board carries out its own activity according to a water management plan. The Alto Adriatico water board has only recently started to support studies about impacts of climate change
In 1907 the Venice Water Authority, a local agency of the Ministry of Infrastructures and Transportation, was appointed as water security and management authority for the Venice lagoon and all water basins directly or indirectly connected with the lagoon hydraulics. Competences included production of knowledge, planning of measures and carrying out of hydraulic works. In time, the Venice Water Authority jurisdiction, that used to span to almost all North-east of Italy, has been limited to the lagoon basin, being the rest of the territory managed by the regions. Any water related work in the lagoon has to be done in agreement with the Venice water Authority. The Venice Water Authority is in charge of overseeing the construction of the storm surge barriers at the lagoon inlets
The Veneto region has approved the Regional Water Protection Plan in 2009. The plan includes recommendations for dealing with climate change impacts (e.g. designing sewerage systems taking into account more intense precipitation due to climate change)
The Consortia for the management of reclaimed land carry out works to ensure hydraulic security in the reclaimed land. They have been calling for major interventions to prevent climate related impacts for several years already

A large number of non-governmental actors, their coalitions and networks actively contribute to the socio-economic life of the Venice lagoon (see Table 1.4). Most of them are commercial and artisan actors directly or indirectly related to the tourism sector. Next to that, dozens of public and private associations, foundations and institutes operate in the field of restoration and valorization of the historical city of Venice, including an UNESCO office in Venice. Scientific knowledge is produced by two universities, public research institutes and private consultancies. Nature conservation is supported by a number of environmental NGOs and citizen's groups since the 1960s (e.g. Italia Nostra, WWF). The presence of the industrial area also brings into the picture labor unions, industrial associations and the port authority. The clam fishing sector is represented by a recently established consortium for clam farming.

Table 1.4 Governmental and non-governmental stakeholders acting in the Venice lagoon

Categories	Organizations
Governmental actors from national to local level	* Ministry of Infrastructure and Transport – Venice Water Authority Ministry of Environment and Protection of Land and Sea Ministry of Defence (it manages part of the Arsenale, the ancient shipyard become later a military area) Ministry of Finance – Agency for Management of Government Property (Demanio) Ministry of Cultural Heritage and Cultural Activities – Venetian Superintendencies Ministry of Education, University and Research * Veneto Region Provinces: Venice, Padua + Treviso and Vicenza in the catchment basin Municipalities: *Venice, *Chioggia and *Cavallino-Treporti in the lagoon + 105 municipalities in the catchment basin
Actors deriving from the Special Law for safeguarding Venice (in addition to the governmental actors highlighted with the *	National government – Inter-ministerial Committee ex art. 4 L. 798/84 Ufficio di Piano ex DPCM 13 febbraio 2004 Safeguarding Commission for Venice (Law 171/73, art. 5) Venice Municipality - Commissioner for Boat Traffic (not in charge anymore since 2008) Venice Municipality - Insula S.p.A. Venice Municipality - Tidal Forecasting and Early Warning Center Venice Water Authority – Consorzio Venezia Nuova
Other public actors for ecosystems and environmental management	Extraordinary Commissioner for the Environmental and Socio-economic Emergency related to the Filling up of the Big Navigation Channels in the Venice Lagoon Extraordinary Commissioner for the Emergency related to the Extreme Weather Events that caused the 2007 Flood in Mestre ARPAV – Veneto Region Agency for Environmental Protection Alto Adriatico Water Board Land Reclamation Consortia in the Veneto Region Conference of Services for the Implementation of the Agreement on the Chemical Production in Porto Marghera Venice Municipality – Institution for the Park of the North Lagoon
Actors for conservation and valorization of natural, historical, cultural, artistic and	UNESCO- Roste, Venice Office International Private Committees for the Safeguard of Venice Venice in Peril – The British Committee for the Preservation of Venice Dozens of cultural foundations, associations and public and private institutes: e.g. Venice Foundation; Cini Foundation; Querini Stampalia Foundation; Biennale Foundation; Venice

Categories	Organizations
architectural heritage	Municipality – Civic Museums Foundation; Ministry of Cultural Heritage and Cultural Activities - Marciana National Library; Veneto Institute of Science, Literary and Art; Venice Society for Natural Sciences; etc.
Actors for knowledge generation	National Research Council - CNR-ISMAR Ca' Foscari University of Venice University IUAV of Venice Ministry of Environment – Institute for Environmental Protection and Research (ISPRA) Ministry of Education, University and Research – Consortium for Coordination of Research Activities Concerning the Venice Lagoon System (CORILA) Venice Municipality and Venice Province - Consortium for Research and Educational Training (COSES) Thetis – Knowledge and engineering for the lagoon environment
NGOs for environmental protection	Environmental protection associations e.g. Italia Nostra, WWF, VAS - Ambiente Venezia, etc. Citizens groups e.g. No-MOSE
Actors related to leisure and recreation	Traditional rowing and sailing boat associations (gondola, voga veneta, etc.) Pleasure Boat Association - Assonautica, Venice Office Shipyard Consortia
Actors related to the tourist sector	Retails and Accommodation companies and associations Tourist and Environmental Guides Association Consortia for the management of Venice, Jesolo, Cavallino-Treporti, Sottomarina beach Environmental tourism associations e.g. Associazione Cultura Turismo Ambiente
Actors related to industrial, commercial and tourist port	Venice Port Authority Special Company for the Port of Chioggia - ASPO Italian Coastal Guard – Harbourmaster Venice Terminal Passengers S.p.A.
Actors related to transport of people and goods	Venice airport - SAVE Nicelli Airport at Lido Cooperatives for private transport of goods Company for public transport of people – ACVT Cooperatives for private transport of people
Private actors related to industrial and craft production	Industrial Association Artisans Association (including artistic glass artisans) Labour unions Board for the Marghera Industrial Zone (Ente Zona Industriale Marghera)
Actors related to fishing and agriculture sectors	Clam Fishing Association - Management of the Lagoon Clam Fishing Resources (GRAL) Farmers and horticulture producers and their association Recreational fishing associations
Actors related to communication	Local and regional newspapers: e.g Il Gazzettino, La Nuova Venezia, Il corriere del Veneto, etc.. Local and regional radio/TV stations: e.g. Rai Tre Veneto, TeleVenezia, Teleregione, etc.

1.2.5 The need of reconsidering the current governance arrangements

The present social, political and economic situation in Venice suggests that the safeguarding of Venice as it was designed by the Special Law more than 30 years ago is at a turning point. In the 1970s safeguarding Venice became a national priority having as goals the protection of the city from tidal floods, the environmental restoration of the lagoon and the socio-economic development of the Venice area. At present, most of the safeguarding infrastructure has been completed or is well under construction. The hard coastal defense infrastructure has been completed (jetties, sea walls, embankments); the storm surge barriers are expected to be finished by 2014; local defenses in the lagoon urban areas have been completed and those in the city of Venice will be completed by 2030 if a regular flow of financial resources will be available. Interventions to restore the lagoon morphology are well undergoing with a new morphological restoration plan about to be approved. A number of water pollution abatement measures in the lagoon have been completed, others are being constructed; in the catchment basin, however, water pollution abatement interventions are behind schedule. The implementation of these safeguarding measures has generally improved the hydraulic security and the state of the environment of the lagoon although water quality objectives have not been fully achieve yet and erosion is still an issue for the existence of the lagoon (Ufficio di Piano 2008a).

According to Dente and colleagues (2001) Special Law did not succeed to establish an effective governance system in the lagoon, however. They argue that the centralized governmental system set by the Special Law failed mostly because the coordinating institutions (i.e. the Inter-ministerial Committee and the Safeguarding Commission) add up to the decision-making process instead of simplifying it.

At present, there is a conviction among some policy-makers that the safeguarding priorities have changed. The political debate has lately turned to the economic development of the Venice area and its connections to the inland territory, the management and maintenance of the hydraulic defense infrastructure, the maintenance of buildings and infrastructure in the city of Venice. In particular, the re-development of the industrial area and the development of the commercial port have been subject of political discussion as reported by the local media. Associated to these issues there are a number of governance needs that have recently raised to the attention of the policy-makers and are strongly interrelated. These are:

- governance of water and the environment;
- governance of the safeguarding intervention and in particular the need to reform the Special Law;
- governance of the storm surge barriers;
- governance of the economic development of the Venice region and in particular the need to define the future of the industrial port and that of the commercial port in Porto Marghera.

In addition to that, between 2008 and 2009 after several years of relatively stable political situation some changes occurred that are now facilitating the emergence of new coalitions among public actors and between the public and the private sector. These new coalitions call for major institutional reforms of the Special Law for Venice. In this discussion about the new Special Law, climate change is not an issue in the agenda of local and national policy-makers. Furthermore, none of the involved actors seems to address the governance of the lagoon in a comprehensive perspective. Finally, the design of a novel governance system for the lagoon seems to be driven by political and individual interests rather than an evaluation of the strengths and the weaknesses of the current institutional system and the recognition of the local actors needs. It seems that the few attempts to evaluate the governance system of the lagoon (Dente et al. 2001) and to address it from an Integrated Coastal Management perspective (see Giupponi et al. 2001; Giupponi & Brochier 2001; Suman et al. 2005) do not have informed the political agenda.

Summarizing, on the one hand the emergence of new governance demands supported by new coalitions of actors is increasingly evident in the Venice system; on the other hand, the governance of the lagoon has never been addressed in a comprehensive way, seems not to be guided by an evaluation of the effectiveness of the existing institutional arrangements and does not include climate change in the discussion. In all this a scientific gap can be recognized: the need to diagnose the existing institutional system, i.e. to identify barriers and opportunities in search for solutions for a novel governance system of the Venice lagoon. This research has as one of its goals to provide information that can be useful for the development of an adequate institutional system for the long term management of the Venice lagoon, including the storm surge barriers operation.

1.3 Research objective and research questions

In the previous sections, the need for novel governance approaches for water and environmental management in the Venice lagoon were pointed out. Against this background, the objective of this study is to explore institutional arrangements for water and environmental management that would improve effectiveness in the governance of the Venice lagoon under conditions of climate change. The focus of this study is on water and environmental governance of a coastal system (the Venice lagoon) for which climate change is one of the issues adding to the complexity. This means that this research is not about governance of climate change in the Venice lagoon.

The core question addressed in this research is therefore: ***How can governance arrangements for water and environmental management in the Venice system be reformed in a way that improves effectiveness***[3] ***in the context of changing climatic conditions?***

The core question was addressed by answering the following sub-questions.

Chapter 2 - Analysis of measures for flood protection in the Venice lagoon:

1. *Will measures that are being carried out within the Special Law regime to protect Venice from flooding be adequate also under the expected accelerated sea-level rise induced by climate change?*
    a. *What are the sea-level rise projections and the expected frequency of flooding in Venice by 2100?*
    b. *What measures have been taken to protect Venice from flooding?*
    c. *Will these measures still be adequate under the expected sea-level rise induced by climate change?*

Chapter 3 - Comparative study to assess adaptive capacity to climate change:

1. *Do relevant institutions for water and environmental management support adaptive capacity to climate change in the Venice lagoon and in the Wadden Sea?*

[3] Degree to which objectives are achieved and the extent to which targeted problems are resolved. In contrast to efficiency, effectiveness is determined without reference to costs and, whereas efficiency means "doing the thing right," effectiveness means "doing the right thing" (Business Dictionary, 2009).

2. *In what physical and institutional aspects are the two regions different and in what aspects are they similar?*
3. *Do different institutions in the two regions produce similar or different outcomes in terms of adaptive capacity to climate change?*
4. *What can these regions learn from each other to improve adaptive capacity to climate change?*

Chapter 4 – Exploring the level of implementation of adaptive co-management in the Venice lagoon and its consequences:

1. *To which extent is adaptive co-management currently practiced in the Venice system?*
2. *What are the effects of implementation or non-implementation of the adaptive co-management prescriptions in terms of learning?*
3. *How is learning related to the implementation or non implementation of adaptive co-management?*

1.4 Data and methodological approach

This study is an explorative case study research. The case study is the Venice lagoon. Three different studies were conducted through a qualitative analysis of different sources of data including scientific literature, archive data and interviews. A comparative study between the Venice lagoon and the Dutch Wadden Sea was also conducted (see chapter 3). The analysis of the Dutch Wadden Sea was performed by a fellow researcher, while we did together the comparative analysis. In the following, the data and the methodological approach refer to what I did for the three studies of this thesis.

1.4.1 Data

Archive data used in this study (available either on the Internet, libraries or on request to the organizations producing the data themselves) are the following:

- Legal documents: European regulation on water and nature management (i.e. Water Framework Directive and Birds and Habitat directives) and relative national and regional regulations to implement them; national laws and related

regional and local regulations on the safeguarding of the Venice lagoon (the Special Law for Venice) since 1973; ministerial decrees and official documents about decisions on the safeguarding works.

- Policy, program and plan documents derived from the Special Law and those derived from the EU, national and regional legislation listed above; additional programs and plans document that the public organizations adopted to achieve the Special Law goals.

- Assessment and thematic reports of national, regional and local agencies and research centers. These organizations are: Ministry of Environment and its technical agency ISPRA; Venice Water Authority and the concessionaire Consorzio Venezia Nuova; Veneto region and its technical agency ARPAV; Venice Municipality and its technical agencies INSULA and COSES; Venice Province; Ufficio di Piano; Co.Ri.La.; National Research Council; UNESCO-Venice office. The material deals with: financing of the safeguarding works, state of the environment of the Venice lagoon (i.e. water, sediment and ecosystems quality); natural and socio-economic pressures and impacts on the lagoon environment (i.e. climate change, clam fishing, commercial and industrial port, tourism); socio-economic development issues (i.e. industrial and commercial port activity, tourism, redevelopment of the industrial area);

- International, national and local newspaper articles collected between 2004 and 2010 through a daily press clipping service on Venice issues; the articles deal with the safeguarding of Venice, water and environmental management.

- Reports, articles and documents published (either on the website or on paper) by a number of NGOs and citizen groups active on Venice safeguarding issues: Italia Nostra Venice Office, Assemblea Permanente NoMOSE, WWF, Associazione Ambiente Venezia, VAS–Verdi Ambiente Societá, Eddyburg.it by Edoardo Salzano, Venice in Peril Fund.

The scientific literature includes journal articles and books dealing with: climate change and adaptation in coastal regions; environmental governance; sea-level rise projections and impacts in the Venice region; Venice lagoon safeguarding, management and environmental issues.

The documental material was supplemented with seventeen interviews conducted between March and June 2010. Interviewees included scientists, policy-makers, public officers and practitioners dealing with water and environmental management in the Venice lagoon. They were selected on the basis of their knowledge on the issues being studied and their affiliation to relevant institutions dealing with water and environmental management. Nine interviews were specifically conducted for this thesis, asking questions about the governance of the Venice lagoon and of the mobile barriers, climate change and adaptation policy in Venice. Questions asked on governance regarded options and challenges for the safeguarding of Venice, the effectiveness and the impacts of the existing institutional arrangements, the visions for the future of Venice and the policy needs to reform the current institutional system. Questions about climate change revolved around sea level rise and climate change scenarios and impacts and policy for adaptation. The remaining six interviews were conducted with a fellow researcher[4] on the topic "Policy and measures for adaptation to climate change in the Venice lagoon". The transcripts of the interviews together with notes taken during the interviews were used for the analysis. The environmentalists' perspective was covered through documental material as I could not interview their representatives (the contacted person suggested to refer to the website to gain insight on the group's perspective). Respondents asked anonymity; therefore the list of interviewees is not provided.

In addition to that, I have firsthand experience of the functioning of the formal and informal institutional system at work in Venice. This experience comes from more than 6 years working for the *Ufficio di Piano*, a technical committee of policy-makers and scientists advising the national government on priorities to safeguarding Venice and its lagoon from a physical, environmental and socio-economic perspective. As member of the technical secretariat of the Ufficio di Piano: I attended all 67 UdP meetings from October 2004 to December 2010 including those (about one third) to which experts (policy-makers, practitioners and scientists) were invited to report on specific issues regarding the safeguarding of Venice; I had opportunity to have informal meetings with the members of the committee and the experts invited to report at the UdP; I was involved in the drafting of all the UdP advisory documents and thematic reports; I participated to all work sites inspections the Ufficio di Piano went to, including the yearly inspection to the mobile barriers work sites and the inspections to other work

[4] N. Marinova, Alterra Research Institute/Wageningen University

sites such as the locale defenses works, banks reconstruction works in Porto Marghera and morphological reconstruction works.

Experts invited by the Ufficio di Piano to share their findings and knowledge on socio-economic and environmental aspects of the safeguarding of the Venice lagoon included representatives of international organizations, national, regional and local authorities (UNESCO, Ministry of Environment, Veneto region, Venice province, Venice municipality, Chioggia municipality, Venice Water Authority); representatives of their public or private agencies (Consorzio Venezia Nuova, Insula, ARPAV, GRAL); scientists of different research institutes (National Research Council-ISMAR, University of Ca' Foscari-Venice, CORILA, IUAV University of Venice, University of Padova). The meetings were done in form of hearings at the regular Ufficio di Piano meetings.

Although most of information of the Ufficio di Piano meetings (i.e. minutes, notes taken at the meetings, presentations, a number of reports and project documents) is confidential and could not be directly used for quotation in this study, the knowledge I gained in these years helped identifying relevant sources of data and information, relevant stakeholders representing different scientific, environmental, social and technical perspectives on the safeguarding of Venice and on climate change. It also proved to be useful to select and to have access to the interviewees. The knowledge about the informal institutional system was also important for interpreting the results of the analysis. The perspective from which I could gain knowledge about the Venice system is, in fact, quite a privileged one as I had the opportunity to work at the interface between policy-making and science. This job, together with my natural science background, gave me the opportunity to understand the system from both sides, scientific and political. Thanks to my scientific background I could understand current problems and future threats for the existence of the lagoon from a scientific point of view. By working for the Ufficio di Piano, then, I learnt to understand the political and policy-making dimensions. Particularly, I could gain knowledge about: how the policy for the safeguarding of Venice has developed and what it has brought about in the past 30 years; the role of informal institutions, existing coalitions and networks in steering policy decisions; the power relations among different public actors and between public and private actors; the role of the civil society in influencing policy. This allowed me to learn to dialogue with both policy-makers and scientists, understand their reasons, questions and needs and turned to be extremely useful for my analysis.

1.4.2 Methodological approach

Since the early stages of this study, I realized that my situation as PhD student was somehow different from that of most fellows. I, in fact, had deep understanding and knowledge of a specific case study, i.e. the Venice lagoon, and I wanted to search for solutions to problems I considered relevant (see later on this paragraph for explanation) but I lacked proper scientific and theoretical background to look into it. For a regular PhD student the other way round most often applies: he/she has a reasonably good theoretical basis from which formulating his/her research hypothesis and questions and he/she searches for good case studies to test them. After acknowledging that my situation was different, I started searching for a novel perspective. I then decided to frame this study as my own professional experience moving from several years working for public actors and scientists to doing research. This required changing from a working mind-set to a research mind-set. What I immediately recognized as crucial to do my research was to take a step back from the position I was with my job dealing with the safeguarding of Venice and try to look at the Venice system from an objective perspective to avoid being biased. To ensure the impartiality of the analysis, I needed to look to the object of my study, i.e. institutions for water and environmental management, from different perspectives. To do that, I needed different theoretical frameworks. In fact, if different approaches would lead to similar findings I could be confident enough of not being guided by my point of view.

Because I wanted to explore both climate change and environmental governance issues I first needed background knowledge on both field of research. So, I, firstly, conducted a literature review on these two streams of literature. The literature review on climate change impacts and adaptation strategies in coastal regions and that on environmental governance provided the understanding of the research area, the theoretical frameworks to analyze the case and helped defining my research questions. The chosen theoretical frameworks are the following:

- structural vs non structural measures framework for looking into climate change adaptation options (chapter 2);
- the Adaptive Capacity Wheel methodology for assessing adaptive capacity of institutions to climate change (chapter 3);

- the adaptive co-management framework for improving effectiveness of environmental governance systems in the context of global environmental change (chapter 4).

The three approaches are quite different. The first one is broad and flexible. These characteristics allowed giving a wide overview of measures and institutions at work in the case study area and to evaluate them in terms of climate change adaptation. The second approach is more empirical and offered the opportunity to assess the object of the study, i.e. institutions, in a systematic way and to conduct a comparative study. Finally, the literature proposes the adaptive co-management as normative framework to improve governance effectiveness in the context of global environmental change. Climate change is one of these global changes and it is the one I wanted to explore in my study. This framework, therefore, links the governance of the environment to climate change. At the same time this framework does not only deal with governance of adaptation but it takes a much broader perspective on institutions. This is exactly what I was looking for. In fact, the focus of my study is not on governance of adaptation but water and environmental governance in a coastal system, i.e. the Venice lagoon, where climate change is only one of the issues contributing to the complexity for the management of the environment.

The research questions and the theoretical frameworks, then, guided the selection of the data and the information in a structured way. To answer the core research question a qualitative analysis of the data was conducted in three separated studies responding to the sub-questions listed in section 1.3. First, scientific literature, legislative and policy documents, assessment and thematic reports and studies published by local research institutes and governmental agencies were used to reconstruct the key features of the environmental, social and governance systems in the Venice lagoon and to identify measures implemented for the safeguarding of Venice. Secondly, all data and information obtained from the documental material and the transcripts of the interviews were analyzed and interpreted according to the theoretical frameworks. Finally, reflection on the findings led to formulate recommendations to improve effectiveness in the governance of the Venice lagoon.

1.5 Outline of this dissertation

This dissertation is organized as collection of papers. Each chapter (except for chapter 1, 5 and 6) is based on a different article written by the author together with other fellow researchers. These articles were written to be published as independent publications and therefore some overlap between them in the description of the case study could not be avoided. However, because each paper analyzes the case study from a different perspective and this required to bring to light different aspects of the physical, environmental and institutional system of the Venice lagoon, these overlaps are limited.

Chapters 2, 3 and 4 are the core of the analysis and answer the research questions presented in paragraph 1.3. Chapter 2 discusses the ongoing measures to protect Venice from tidal flood with respect to the expected acceleration of sea-level rise in the Venice region by 2100. Chapters 3 and 4 focus on institutions for water and environmental management. In chapter 3 a tool is used to assess the adaptive capacity of institutions to climate change in Venice. In depth understanding and recommendations come from the comparison with a Dutch case, the Wadden Sea. Chapter 4 combines the knowledge gained about institutions in Venice and analyzes it according to the prescription of the adaptive co-management framework. Understanding about to what extent adaptive co-management takes place, effects of implementation or non-implementation of the adaptive co-management prescriptions in terms of learning and relations between the two is presented. Chapter 5 summarizes the main findings of this study and reflects on its limitations. Finally, picking up on the conclusions of chapter 2, 3 and 4, chapter 6 answers the core research question by pointing to the key issues emerged in this study and addressing them with recommendations. Based on the experience of Venice, the chapter also draws some conclusions about how people living in lagoons can govern in an adaptive way their territory and natural resources under changing climatic conditions.

2 Measures to protect Venice from flooding under the threat of sea-level rise

Abstract

It is widely acknowledged that, in times of climate change, loss of coastal resources and risk for human life can be minimized by implementing adaptation strategies. Such strategies need to encompass a balanced mix of non-structural and structural measures grounded on sound scientific knowledge.

This paper discusses measures carried out to protect the city of Venice (Italy) from flooding (locally known as “high waters”), and reflects on their ability to anticipate a possible acceleration of sea-level rise as induced by climate change. It is based on peer reviewed scientific literature; legislative and policy documents of key institutions; reports and documents of organizations working on Venice issues; newspaper articles; and interviews.

Our analysis shows that the synergic action of the hydraulic defense infrastructure under construction is, in principle, adequate to withstand a broad range of sea level rise scenarios for the next 100 years. However, when the goal is to use these investments effectively, major changes in the existing institutional arrangements will be required in the years to come.

The Venice findings point out the difficulties and yet the importance of identifying and implementing a balanced mix of structural and non-structural measures to adapt to climate change.

Key words: coastal management, climate change; storm surge barriers; environmental governance; institutions

Chapter to be published as:
Munaretto S., Vellinga P. and Tobi H., Protecting Venice from tidal floods under the threat of sea level rise

S. Munaretto conduced the planning and the analysis of the study, and wrote the paper. P. Vellinga supervised the analysis, contributed to the discussion and to the revision of the paper. H. Tobi contributed to design of the structural framework of the paper, the methodology, and the revision of the paper.

2.1 Introduction

Adaptation has been worldwide acknowledged as a strategy to cope with the unavoidable impacts of climate variability and change (IPCC 2007a; EC 2009a). In recent times, climate research has been greatly committed to developing adaptation strategies and measures to deal with sea-level rise (SLR) in coastal areas (IPCC 1990a, 2007a; EC 2009a).

Traditional coastal defense strategies, i.e. building defense infrastructure, can no longer be assumed as the only possible response in coastal areas at increasing risk due to SLR (Kundzewicz 2002; Few et al. 2007). Scientists and practitioners alike conclude that a balanced mix of *non-structural* and *structural* measures grounded on sound scientific knowledge is crucial to maintain ecological, economic and social coastal functions[5] under changing climatic conditions (Smith & Lenhart 1996; Smit et al. 1999; Wheaton & Maciver 1999; Kundzewicz 2002; Kabat et al. 2005; Smit & Wandel 2006). Non-structural measures include legal, institutional, and organizational measures such as legislation, policy, regulations, management and planning instruments, organizations and informational system for coastal ecosystems and resources management (Smith & Lenhart 1996; Smit et al. 1999; Kundzewicz 2002). Structural measures include *hard* (e.g. sea walls, dikes, dams, storm surge barriers, diversions) and *soft* (e.g. beach nourishment, salt-marsh protection and reconstruction) technological and engineering infrastructures often designed for long term functioning.

Planning and implementing multiple options requires complex decision-making and novel approaches to coastal resource management (Few et al. 2007). Major legal, institutional, financial and organizational barriers need to be addressed (IPCC 2007a; EC 2009a). Because adaptation responses strongly depend on specific local geographical, climatic and socio-economic characteristics of coastal regions (IPCC 2007a) sound scientific, technical and resource management knowledge need to be tailor-made at local level.

Venice and its lagoon is a well known example of a complex and vulnerable artificially conserved natural system (Bevilacqua 1998; Ramieri 2000; Ravera 2000; Musu 2003; Rinaldo 2009). Similarly to many other coastal regions, SLR is expected to increase

[5] Important coastal functions include regulation of hydrological flows, formation and retention of soil and silt, storm protection and flood control, retention and processing of nutrients and organic matter, providing habitat for biodiversity including regional harvested species, providing food (e.g. fish), opportunities for recreational activities and non-commercial uses (aesthetic, artistic, educational, scientific), waste assimilation, pollution control and detoxification, opportunities for transportation, space for housing (Costanza et al. 1997).

erosion, the frequency, intensity and height of tidal floods (locally called *acqua alta*, meaning high water) and loss of habitat and biodiversity. In the 1970s, safeguarding Venice and its lagoon became a national priority in response to an extreme high water that flooded the city with almost 2 meter of water above mean sea level in the year 1966. To protect Venice and its lagoon from such high waters and other natural and human-induced hazard, the Italian government established a legal framework known as the Special Law for Venice. This framework consists of a number of national laws and ministerial decrees that sets objectives, administrations' responsibility, regulations, actions and measures, and allocates funds for safeguarding Venice and its lagoon. National, regional and local authorities are in charge of programs implementation (Bevilacqua 1998; Amorosino 2002).

The main goal of the introduction of the Special Law was to protect Venice and the other lagoon settlements from high waters. The Special Law dates back more than 30 years, when climate change and the acceleration of sea level rise was not a major concern. Today we know that SLR is likely to accelerate, and consequently high waters are likely to increase faster than anticipated when the plans were made. Against this background, the following key question is raised:

- *Will measures that are being carried out within the Special Law regime to protect Venice from high waters be adequate under the expected accelerated SLR induced by climate change?*

The question is addressed by answering the following three sub-questions:

- *What are the SLR projections and the expected frequency of high waters in Venice by 2100?*
- *What measures have been taken to protect Venice from high waters?*
- *Will these measures still be adequate under the expected accelerated SLR?*

Answers were obtained by analyzing legislative and policy documents, assessment reports, newspaper articles, scientific literature, and interviews. The findings were, then, linked to the SLR scenarios in the Venice region and the expected increased frequency of high waters by the year 2100.

The following sections describe methodology and data (section 2.2), review SLR and high waters projections for Venice (section 2.3), illustrate the measures to protect

Venice from high waters (section 2.4) combine the findings of section 2.3 and 2.4 (section 2.5). Section 2.6, finally, discusses our results and draws the conclusions.

2.2 Data and methodological approach

Information presented in the following sections was obtained from scientific literature, archive analysis and interviews. The collected documentation included pieces of laws and regulations; policy, plan, programs documents; assessment and thematic reports; newspaper articles; and notes and transcriptions of interviews.

Sea-level rise and high water trends and projections for the north Adriatic and Venice were derived from scientific literature and studies conducted by local agencies, i.e. the Venice Water Authority, the Venice Municipality-Tidal Forecasting and Early Warning Center, the Consortium for Coordination of Research Activities Concerning the Venice Lagoon System (Co.Ri.La.), the National Research Council-Venice Office and Città d'Acqua. This information was used to answer the first research question.

To answer the second research question, first the climate adaptation literature was reviewed in search of a framework for interpreting the measures in terms of adaptation. Then, information was analyzed according to this framework to identify what type of adaptation is or is not taking place in Venice, i.e. structural vs. non-structural measures.

Most of the documents that have been analyzed to answer the second research question are results of the Special Law for Venice regime. The body of Special Law themselves have been analyzed to understand the institutional system existing in the Venice lagoon in order to identify key organizations, responsibility, relevant policy and plans documents. From these documents it was possible to reconstruct the non-structural measures (legal, institutional and organizational) (see Figure 2.5 and Table 2.2). From the documentation of the administrations in charge of the protection from high waters (i.e. Venice Water Authority and Venice Municipality) and those of their project developers (i.e. Consorzio Venezia Nuova and Insula S.p.A.) the structural measures could be identified and described.

To understand how structural and non-structural measures in Venice relate to SLR and high water trends and projections and therefore answer the third research question, the first two sets of information were combined. This was done by comparing a best

estimate for the upper bound SLR scenario with the technical characteristics of the structural measures being taken.

The analysis was facilitated by the fact that the first and the second author of this paper have firsthand experience on the functioning of the Venice system having worked in the role of researcher (Munaretto) and of expert member (Vellinga) of the Ufficio di Piano (UdP) for the past 6 years. This is a technical committee advising the national government on priorities to safeguarding Venice and its lagoon from a physical, environmental and socio-economic perspective. We were involved in the preparation of and attended the 67 UdP meetings from October 2004 to December 2010; this including those (about one third) to which experts (policy-makers, practitioners and scientists) were invited to report on specific issues regarding the safeguarding of Venice (including the high water issue). We also were involved in the drafting of the UdP advisory documents and thematic reports. Most of this information (minutes, notes, presentations) is confidential and could not be directly used for quotation in this study. We did use the UdP advisory documents and thematic reports that are public available.

Moreover, to gain understanding about different perspectives on the protection of Venice from high waters and their evolution in time, we analyzed press information collected over the past six years thanks to a daily press clipping service on Venice issues. We also analyzed reports, articles and documents published by environmental groups and other NGOs actively working on Venice issues (i.e. Italia Nostra-Venice Office, Assemblea Permanente NoMOSE, WWF, Associazione Ambiente Venezia, Eddyburg.it by Edoardo Salzano, VAS–Verdi Ambiente Societá, Venice in Peril Fund). Finally, we interviewed local policy-makers, scientists and practitioners of local private and public organizations knowledgeable about Venice lagoon safeguarding issues. Sixteen out of seventeen experts contacted were interviewed between March and June 2010[6]. The interviewees were selected on the basis of our experience in the field so as to have as many perspectives as possible on the safeguarding of Venice represented. Notes and transcriptions of the interviews were used in our analysis. The interviewees requested to remain anonymous, and therefore a list of names is not provided and interviewees are only referred to by position. The person that did not accept to be interviewed told us to refer to the website as source of information and opinion of the group (it was an environmental NGO). Questions revolved around climate change

[6] Six interviews were conducted together with a colleague from Wageningen University on the topic climate change impacts and adaptation in Venice

scenario, impacts and adaptation and present and future governance of the Venice lagoon.

2.3 Sea-level rise and its impacts in terms of high waters in the Venice lagoon

The city of Venice has experienced variations of lagoon water level for centuries. The phenomenon consists of a temporary (tidal and surges driven) rise in the sea level that floods part of Venice and the other lagoon urban areas for a few hours[7]. It may occur several times a year, particularly in the winter months. Depending on the magnitude of the event, high water may lead to temporary interruption of economic and social activities and citizen mobility, and damage shop assets and warehouses. In the long term, frequent high waters impair monuments, urban buildings and infrastructure (e.g. catchment systems, canal banks, building foundations, historical and artistic heritage, and lagoon embankments).

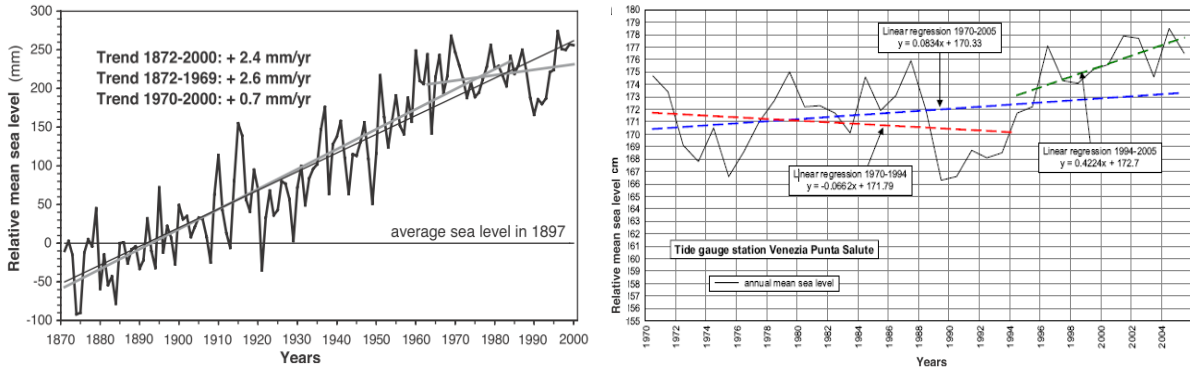
Local land subsidence and global eustatic processes significantly affect mean water level in the Venice lagoon. According to several studies conducted in the past decades by Carbognin and colleagues of the National Research Council (Gatto & Carbognin 1981; Carbognin et al. 1995, 2004, 2009; Tosi et al. 2002; Brambati et al. 2003), the Venetian soil sunk about 23-25 cm relative to the mean sea level over the last hundred years. Twelve cm was lost due to land subsidence, both natural (3 cm) and human-induced because of groundwater extraction (9 cm); 11-13 cm was lost as consequence of global eustatic processes. Since groundwater exploitation has been regulated by law in the 1970s, land subsidence in the city of Venice and the surrounding main land has stabilized at the natural rate between 0.4 mm/yr (Tosi et al. 2002; Carbognin et al. 2004) and 0.8 mm/yr (Antonioli et al. 2009). In the north and south lagoon and in the littorals, however, the rate of subsidence is still about 1-2 mm/yr (Carbognin & Tosi 2003).

The contribution of eustatic processes to the mean sea level in the Venice lagoon is greatly uncertain. Scientists agree upon the existence of fluctuation and the absence of an unambiguous trend (Canestrelli et al. 2001; Pirazzoli & Tomasin 2002; Camuffo & Sturaro 2004; Carbognin et al. 2004; Zanchettin et al. 2006; Ferla et al. 2007).

[7] *Acqua alta* is defined as a tide exceeding +80 cm respect to the conventional zero. The conventional zero is the average sea level measured at *Punta della Salute* station in Venice in 1897 (mean sea level – m.s.l.). A water level of +80 cm m.s.l. starts flooding the lower parts of the city. Exceptional high water is a tide exceeding +110 cm m.s.l. that floods 14% of Venice. Extreme high water is a tide exceeding +140 cm m.s.l., which causes more than 50% of the city to be flooded (Venice Municipality - Tidal Forecasting and Early Warning Center, 2010).

According to Pirazzoli and Tomasin (2002) and Zanchettin et al. (2006), fluctuation is correlated with internal Mediterranean dynamics and possibly solar activity, but the mechanisms are not fully clear, let alone well predicted. Figure 2.1 shows the mean sea level recorded in Venice since 1872 and the trend-line over different time scales. Although a trend of rising mean sea level seems to emerge from the centenary records, on shorter time scale positive as well as negative variation are revealed (Camuffo & Sturaro 2004; Carbognin et al. 2004; Ferla et al. 2007). On average, the eustatic rise excluding the contribution of land subsidence was 1.2 mm/yr since 1890 (Carbognin et al. 2009). However, Carbognin et al. (2009) argues that to establish real trend of mean water level in the Venice lagoon, long-term data sets need to be acquired in order to overcome periodical multi-decadal oscillations.

Figure 2.1 Variation of the mean sea level in the Venice lagoon in 1872-2009 (left side) and focus in 1970-2005 (right side)



Source: Camuffo and Sturaro 2004 (left) and Ferla et al 2007 (right)

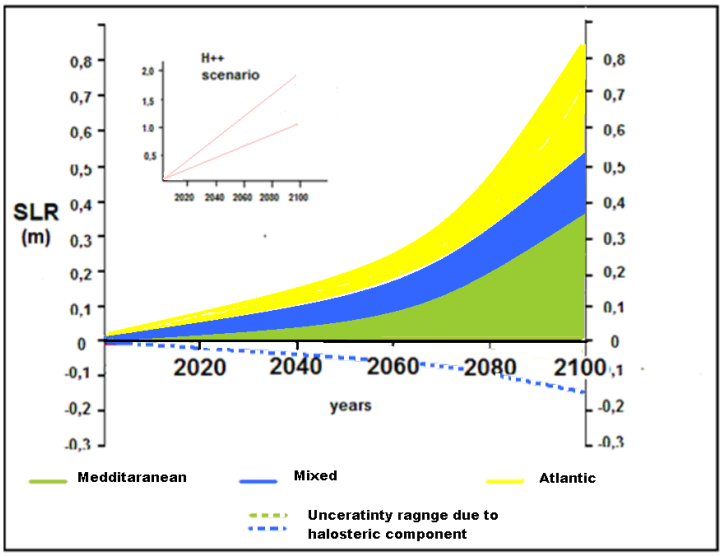
A number of studies (Mag.Acque-CVN 1997; Co.Ri.La. 1999; Plag 2008; Carbognin et al. 2009; Vellinga et al. 2010) estimated future SLR in the Venice region considering global warming contribution to SLR and local land subsidence. Scenarios range from 0.31 m (Co.Ri.La. 1999) up to 1.35 m (Plag 2008) in 2100, reflecting major uncertainties (Table 2.1Table 2.1). Co.Ri.La. considered land subsidence to account for -0.4 mm/yr and calculated the eustatic rise using the IS92a emission scenario of IPCC (1995) and other models that incorporate sensitivity for glacier and ice caps melting. Plag in his 1.35 m SLR scenario considered -3 mm/yr of land subsidence and calculated the eustatic rise using models that incorporate acceleration of Antarctic ice sheet in addition to glaciers and ice cap melting. Both Carbognin (2009) and Mag. Acque - CVN (1997) predicted an upper end (max) SLR of +53 cm in 2100. They used identical rate of land subsidence, but different IPCC scenarios. Mag.Acque used the IS92a emission

scenario of IPCC (1995), and Carbognin used the A1B emission scenario of IPCC (2007c). Plag's (2008) high scenario (1.35 m in 2100) is more than twice as large as other scenarios because it considered an acceleration of Antarctic ice sheet melting. Indeed, the rate of Antarctic melting is one of the major factors causing the large range of uncertainty, which is currently studied by many scientists. The most recent SLR scenarios for Venice have been developed by a group of international experts (Vellinga et al. 2010) and are illustrated in Figure 2.2. The range Vellinga et al. consider plausible is between -16 and +84 cm SLR by 2100, which includes the possibility of mean sea level falling as a result of increased evaporation of the Mediterranean Sea water and increasing due to the contribution of ice sheets melting (still high uncertain). Looking at the above described studies and according to experts' knowledge a value between +30 and +60 cm is most likely by 2100 (*Carbognin, Cescon, Vellinga personal communication, 2010*).

Table 2.1 Sea level rise projection for the Venice region by 2100

Source	Low scenario (m)	High scenario (m)
Mag.Acque 1997	+0.04	+0.53
Co.Ri.La. 1999	+0.16	+0.31
Plag 2008	+0.45	+1.35
Carbognin 2009	+0.17	+0.53
Vellinga et al. 2010	-0.16	+0.84

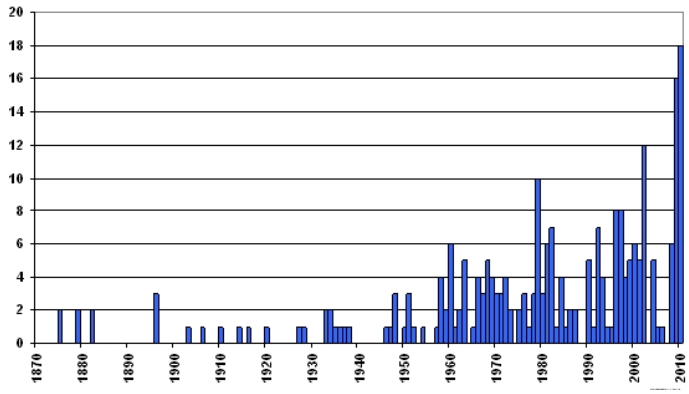
Figure 2.2 Sea level rise scenarios for the Venice region at the end of the 21st century



Source: (Vellinga et al. 2010)

Because of the described processes, the frequency of high water events has increased in Venice over the past one hundred years. Accelerated SLR as a consequence of climate change is likely to exacerbate this trend in the decades to come, even though other scenarios cannot be excluded. Exceptional high waters increased from 1-2 times per year in the period 1872-1955 to 8-10 times per year in the period 1955-2010 (Figure 2.3). Even extreme high waters seem to have become more frequent: between 2008 and 2010 three of the highest events ever recorded occurred. According to the estimates of Mag.Acque (1997, Figure 2.4-left), a mean sea level 30 cm higher than present time would imply extreme high waters to flood the city of Venice three times a year on average. A more recent estimate of Scotti (2010) foresees an average of 90 exceptional high water events per year in case of +60 cm SLR by 2100. Carbognin et al. (2009) suggest a much higher number of exceptional events already with +50 cm SLR, i.e. 250 per year (Figure 2.4-right). However, all these estimates are only indicative because important parameters influencing high waters (i.e. barometric pressure, direction and intensity of winds, intensity of precipitation in the catchment basin, and marine circulation) are affected by great uncertainty at regional and sub-regional scale (Ramieri 2000). For example, Pirazzoli and Tomasin (1999) found a decline in the frequency and strength of the Bora wind, an intensification of the Scirocco wind, and an increase of atmospheric pressure which may be in part connected to inter-decadal climate variability but also to a climatic shift due to global warming. In terms of frequency, height and intensity of high waters, a reduction of the Bora wind and an increase of atmospheric pressure act positively (i.e. reduce high waters), whereas an intensification of the Scirocco acts negatively (i.e. increase high waters).

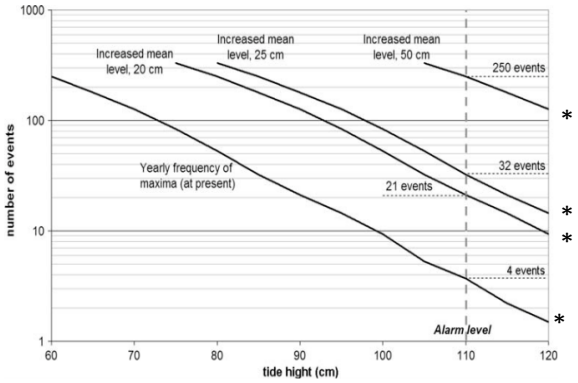
Figure 2.3 Annual frequency of exceptional high water events (with level equal or above +110 cm m.s.l.) in Venice between 1872 and 2009



Source: Venice Municipality - Tidal Forecasting and Early Warning Center, 2010

Figure 2.4 Expected frequency of high water peaks according to four different SLR scenarios

Tidal peaks (cm)	Mean annual frequency for current m.s.l.	Mean annual frequency for m.s.l. +10 cm	Mean annual frequency for m.s.l. +20 cm	Mean annual frequency for m.s.l. +30 cm
+80	39	94	204	356
+100	7	16	39	94
+120	1	3	7	16
+140	1/6 y	½ y	1	3



Source: (Mag.Acque-CVN 1997 p. 80, left) *and* (Carbognin et al. 2009, right)

* All estimates refers to the year 2100

2.4 Measures to protect Venice from high waters

The following sections illustrate measures that are being taken to protect Venice from high waters according to the non-structural/structural measures framework (see section 2.1). The Special Law for Venice addresses, by means of both structural and non-structural measures, issues such as coastal defense, pollution abatement, nature conservation, hydraulic equilibrium of the lagoon, maintenance of historical, cultural, architectural and environmental heritage, promotion of socio-economic development. It is outside the scope of this study to illustrate all of them. However, in order to make clear the complexity of the system, we will illustrate the whole architecture of the Special Law in section 2.4.1 (non-structural measures). Then, we will focus on infrastructural works aimed at protecting Venice from high waters in section 2.4.2 (structural-measures).

2.4.1 Non-structural measures: the Special Law for Venice regime

Extreme weather events are often catalysts for change. Indeed, the Italian government started taking actions to protect Venice and its lagoon from high waters and environmental degradation immediately after the 1966 flood, which had caused enormous damages to historical buildings, economic activities and to the lagoon environment (Obici 1967; Amorosino 1996, 2002; Bevilacqua 1998; Rinaldo 2009).

A Special Law for Venice regime was established and regularly funded. The Italian Law n. 171 of April 16th 1973, the Italian Law n. 798, November 29th 1984, and the Italian Law n. 139 of February 5th 1992 are the main laws that set objectives, responsibility,

instruments, measures and economic resources for carrying out safeguarding activities. In the late 1990s, in addition to the laws, the Italian government set water quality objectives and regulated the total maximum load of a number of pollutants specifically for the Venice lagoon and the water bodies of its catchment basin.

The main objectives of the Special Law were protection of urban centers from high waters; protection of coastal strips from erosion and sea storms; re-establishment of the hydro-geo-morphological equilibrium of the lagoon; safeguarding of the environment (both natural and human built); abatement of pollution both in the catchment basin and the lagoon basin; and promotion of socio-economic development of the historical lagoon settlements (Italian Law n. 171 of April 16th, 1973; Italian Law n. 798, November 29th, 1984; see Table 1.1 for reference and details).

To achieve the Special Law objectives, national, regional and local governmental authorities have developed plans, implemented programs and carried out works in the lagoon basin, the catchment basin and the coastal strips. The institutional setting established by the Special Law is depicted in Figure 2.5 and Table 2.2. Each responsible authority (i.e. Venice Water Authority, Veneto Region, Venice and Chioggia municipalities) acts independently through its own program of measures and within its administrative boundary. To increase effectiveness, administrations implement joint actions through specific inter-institutional legal agreements (e.g. Inter-institutional agreement among Venice Water Authority, Veneto Region and Venice Municipality of August 1993 on local defenses in the city of Venice).

At national level, an Inter-ministerial Coordinating Committee (called *Comitatone*), guarantees coordination and control of all safeguarding activities (see Figure 2.5). The committee is chaired by the President of the Council of Ministers and is made up of government ministers and representatives of the local authorities. It mainly allocates funds and takes the most important political decisions regarding the safeguarding measures. In 2004, the Italian government decided to support the Comitatone with a technical advisory Committee, called *Ufficio di Piano*. This is a mixed committee made up of national and international experts on Venice lagoon issues and local policy-makers. Areas of expertise covered are economics, hydraulic engineering, ecology, management and planning, environmental policy and law. Coordinated by the President of the Venice Water Authority, the Ufficio di Piano is a permanent body charged with

the monitoring of progress and advising on priorities for safeguarding Venice and its lagoon.

At local level the responsible authorities are the Venice Water Authority, the Veneto Region, the Venice Municipality and the Chioggia Municipality. In addition there is a local technical committee, called Safeguarding Commission for Venice[8] instituted by the 1973 Special Law. The committee expresses its binding advice to project developers and approving authorities on all building works and territorial transformation planned by private and public bodies within the Venice lagoon. The committee was meant to cease its activity after the planning instruments for the implementation of safeguarding measures had been approved. To date, although the plans have been adopted, the committee still operates. The Venice Water Authority, which is the local representation of the Ministry of Infrastructure and Transport, is in charge of overseeing the planning and execution of the safeguarding measures the State is in charge of. To guarantee rapid and unitary execution of the works, an executive agency of the Ministry of Infrastructure named Consorzio Venezia Nuova (CVN) was established as a concessionaire. This agency is a private corporation made up of Italian construction and engineering companies pursuing public goals. The CVN plans and executes works according to a General Plan of Interventions. The plan was defined and approved, first by the Comitatone and second by the Parliament through the 1992 Special Law. It includes measures to protect urban centers from high waters and sea storms and to improve environmental and ecosystems quality. It also comprises scientific studies and systematical monitoring of the lagoon environment including tidal forecasts (the Venice Water Authority itself carries out monitoring activities in the lagoon as well). The Veneto Region is in charge of abating water pollution in the catchment basin of the lagoon. This is an area of 2.000 km^2 counting 4 provinces, 108 municipalities (including the Venice and Chioggia Municipality) and more than 1 million inhabitants. The region allocates the Special Law funds to local authorities (e.g. municipalities, water bodies, land reclamation consortia) in the territory of the catchment basin through a framework plan of measures named Piano Direttore 2000. The plan includes measures to monitor and reduce pollutants and nutrient load into river tributaries and run-off from the

[8] Members of the Safeguarding Commission are: the President of the Venice Water Authority; one representative of UNESCO; the director of the Superintendence for the Protection of Architectural, Natural, Historic, Artistic and Ethno-Anthropological Heritages of Venice and its Lagoon; the director of the Superintendence for the Museums and Art; the director of the Engineering Maritime Works Office (*Genio Civile per le opere marittime*); one representative of the Ministry of Infrastructures and Transport; one representative of the Ministry of Agriculture; one representative of the National Research Council; 3 representatives of the Veneto Region; one representative of the Venice Province; 3 representatives of the Venice Municipality; 2 representatives of the municipalities at the inner edge of the lagoon . The committee is chaired by the President of the Veneto Region.

catchment basin into the lagoon. The Venice and Chioggia municipalities, finally, oversee and when appropriate intervene in the maintenance of historical, cultural, architectural heritage and of supporting socio-economic development of the city. They act according to their own program of safeguarding measures. To carry out the works the Venice Municipality set up a mixed private-public company called Insula, which executes works such as renovating public infrastructures, dredging canals within the city[9], restoring bridges and buildings foundation, raising city streets and pavements and renovating utility shafts. A specific office of the Venice Municipality funded with the Special Law resources is the Tidal Forecasting and Early Warning Center that elaborates tidal forecast and alert the population in case of expected high water through a system of siren and information panels in the city and cell phone messages.

In addition, since 1998 the industrial area of Porto Marghera located at the internal edge of the lagoon is, along with part of the facing lagoon, formally characterized as a contaminated site of national interest, for the remediation of which the Environmental Ministry is accountable (see Figure 2.7). The area is not included in the Special Law framework but it is worth mentioning as works for the remediation of the site (including dredging works) are carried out by the CVN through several inter-institutional agreements between the Venice Water Authority, the Veneto Region, the Venice Province and the Venice Municipality.

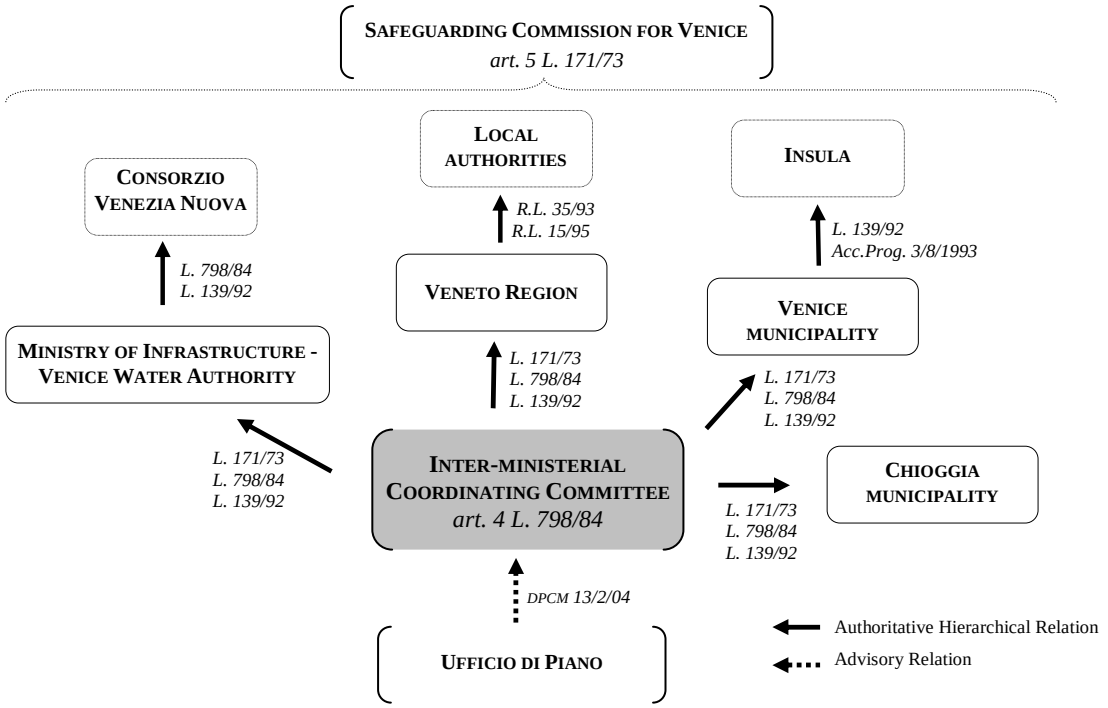
Finally, in recent times the national government has appointed two so called extraordinary commissioners to take care of specific environmental emergency in the Venice area. One commissioner is in charge of dredging the large port navigation channels and disposing of the polluted sediment. The other one is responsible for removing the structural barriers that caused a major flood in Mestre (see Figure 2.7 for location) after an intense rain fall event in 2007. These extraordinary authorities operate for the time required solving the emergency, and are allowed to bypass ordinary laws in order to achieve their goals. They are partially funded by the national government to which they respond. Although they are not within the framework of the Special Law they contribute to make the institutional setting more complex as they interact and may even act in disagreement with local authorities.

Since 1984, the government has allocated about 10.2 billion Euros to achieve the safeguarding objectives, of which 8.8 billion Euros have been spent already (Ufficio di

[9] Dredging of big navigation channels and other lagoon water areas is responsibility of the Venice Water Authority through the Consorzio Venezia Nuova

Piano 2010a). According to the latest funding requirement expressed by the Venice Water Authority, the Veneto Region and the Venice and Chioggia municipality, about 6.1 billion Euros are still required to enable the completion of the safeguarding activities as intended at the time the Special Law regime was passed (Ufficio di Piano 2010a). Distribution of national funds to the local authorities is shown in Figure 2.6. Allocation of funds depends on the type of activities that each administration carries out. The share of funds directly channeled to the CVN, as an agency executing the works, has substantially increased since 2003 when the construction of the storm surges barriers at the lagoon inlets started. Consequently, other administrations had their funds substantially reduced (Ufficio di Piano 2010a). As it can be seen in Figure 2.6, the Veneto region did not obtained additional funding and the flow to the Venice municipality has visibly slowed down since 2003. The reason for this is twofold. On the one hand, the CVN is more effective in spending the resources; on the other hand, the construction of the mobile barriers is absorbing much of the resources for Venice and at present the Special Law is hardly financed.

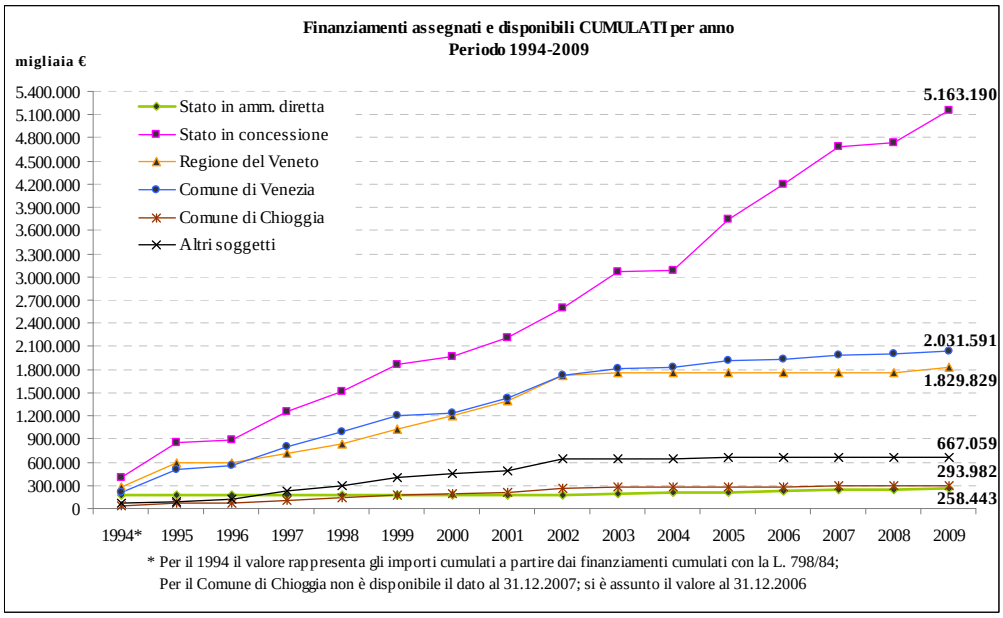
Figure 2.5 Institutional setting established by the Special Law for Venice and other related regulations



Legend: L. = Law; R.L. = Regional Law; DPCM = Decree of the President of the Ministry of Council; Acc.Prog. = Inter-institutional Agreement

Source: our elaboration based on the Special Law for Venice, Government and Ministerial decrees, Veneto Region and local administration regulations and laws

Figure 2.6 Cumulative distribution per year since 1994 of national funds for the safeguarding of Venice allocated through the Special Law



Source: (Ufficio di Piano 2010a)

Figure 2.7 Overview of the location of Venice and Mestre urban centers and the industrial area of Porto Marghera (picture on the right) in the Venice lagoon

Source: adapted from CVN 2010 and Ministry of the Environment, Land and Sea in (Ufficio di Piano 2008b)

Table 2.2 Programs, plans and projects implemented through the Special Law for Venice

Safeguarding objectives	Responsible authority	Instruments to implement the objectives	Measures
Protection from extreme high waters	Venice Water Authority – Consorzio Venezia Nuova	General Plan of Intervention – Protection from extreme high waters	Mobile barriers system at the lagoon inlets
Protection from the most frequent high waters	Venice Water Authority – Consorzio Venezia Nuova	General Plan of Intervention – Local defenses	Raising and structural consolidation of quayside, embankments and public paved areas Protection of ground floor property and rear-lying private and public areas (e.g. courtyards and gardens) from flooding
	Venice Municipality - Insula	Program of Measures to Protect the *Insulae* of Venice	Reorganization and adaptation of the network of underground infrastructure and the drainage system to avoid flow-back through drains
Defense of costal strips from sea storm and erosion	Venice Water Authority – Consorzio Venezia Nuova	General Plan of Intervention – Coastal protection	Dune belt reconstruction Beaches reconstruction Reinforcement of jetties, breakwaters and ancient sea wall
Prevention of environmental degradation and erosion and nature conservation	Venice Water Authority – Consorzio Venezia Nuova	General Intervention Plan - Morphological Restoration Plan	Salt marshes, mudflats and shallows reconstruction and protection Protection of islands from erosion Canal re-calibration Eelgrass planting
Pollution abatement in the lagoon	Venice Water Authority – Consorzio Venezia Nuova	General Intervention Plan – Pollution abatement	Securing industrial canals banks (which is part of the Porto Marghera Master Plan, see below) Securing of former dumps in the lagoon Polluted sediment removal
Pollution abatement in the drainage basin	Veneto Region	Piano Direttore 2000	Construction of sewerage system Adjustment of sewage treatment plant Construction of aqueducts River naturalization Recreation of transitional wetlands and phyto-purification areas Adjustment of drainage network Grant to farmers for green agriculture
Environmental monitoring and tidal forecast	Venice Water Authority and Consorzio Venezia Nuova	Surveillance and Anti-pollution Service Informative Service	Water, sediment, flora, fauna, tide monitoring stations in the lagoon Research and studies (including modeling) on environmental components Tidal forecasting
	Veneto Region	Regional Environmental Monitoring Network	Water monitoring stations in the rivers of the drainage basin and in the Adriatic sea Research and studies on environmental components
	Venice Municipality	Tidal Forecasting and Early Warning Center	Tidal forecasting Early warning system
Historical and non-historical buildings restoration and maintenance; urban infrastructures renovation; socio-economic revitalization of the lagoon urban centers	Venice Water Authority	Three-year Plan of Measures	Restoration of historical buildings owned by the State
	Venice Municipality	Program of Measures for Safeguarding the City of Venice	Restoration of historical buildings owned by the municipality Restoration of public buildings used for social services Grant for private buildings restoration and buying Renovation of bridges, building foundations, city canal shores, drainage shafts and utilities, dredging of the city canals (integrated with public walkway raising; carried out by Insula for the Venice municipality) Buying and urbanization of areas for the settlement of productive activities
	Chioggia Municipality	Program of Measures for Safeguarding the City of Chioggia	
Other instruments for addressing emergencies			
Cleaning up of the Porto Marghera industrial area	Environmental Ministry, Veneto Region, Venice Municipality, Venice Province, other local authorities	Master Plan for the Remediation of Porto Marghera Industrial Area Conference of Services Protocols of Implementation	The industrial area of Porto Marghera is in the national list of the most polluted sites. Its remediation is not directly included in the Special Laws for Venice. Remediation is mostly funded with resources obtained from polluting industries
Dredging of the large port navigation channels and disposal of the polluted sediment	Extraordinary Commissioner for the Environmental and Socio-Economic Emergency Related to the Large Port Navigation Channels in the Venice Lagoon	Program of Measures	Ad hoc interventions, mainly consisting of infrastructures to solve acute situations
Removal of structural causes that were the cause of a major flooding of Mestre in 2007, after an intense rainfall event	Extraordinary Commissioner for the Emergency related to the Exceptional Meteorological Events of 26 September 2007 that have stricken part of the Veneto Region	Program of Measures	

Source: our elaboration based on the Special Law for Venice; policy, program and plan documents of the Veneto Region and the Venice and Chioggia municipality; other authorities' programs and documents (i.e. documents that are cited in the third column of the table)

2.4.2 Structural measures to protect Venice from high waters

Within the framework of the Special Law, the solution that the government chose to protect Venice lagoon urban areas from high waters consists of an integrated system of different measures at the lagoon inlets and in the lagoon urban centers. These measures are part of the General Plan of Intervention of the CVN and the Program of Safeguarding Measures of Insula (see section 2.4.1 and Table 2.2). The total investment for these measures is about 5.9 billion Euros. The amount granted so far is 3.6 billion Euros, representing 35% of the 10.2 billion allocated by the Italian government for the whole safeguarding intervention until 2009. The responsible authorities have so far spent 3.3 billion on studies, projects and infrastructure (Ufficio di Piano 2010a).

Storm surge barriers at the lagoon inlets

At the three lagoon inlets the CVN is constructing a system of storm surge mobile barriers known as the MOSE system (Modulo Sperimentale Elettromeccanico or elecromechanical module, see Figure 2.8). The system aims to protect the city of Venice and the other lagoon settlements from extreme and exceptional high waters by temporarily separating the lagoon from the sea for the duration of the high water event. The system consists of 78 independent floating gates with hinges fixed in the bottom of the inlet channel. In normal tide conditions, the gates lie full of water, flat in their housings buried into the inlet channel bottom. Every time a tide of +110 cm above m.s.l. (so called safeguarding level) is forecasted, the barrier is raised through the introduction of air into the gates that removes water and forces them to float (Fice & Scotti 1990; Mag.Acque-CVN 1992, 2000; Gentilomo & Cecconi 1997; Scotti 2010; CVN 2010) (see Figure 2.9). Navigation passage in and out of the lagoon during closure time is possible through locks at the inlets: one lock for large ships and three small locks for the transit of fishing boats and other small vessels such as yacht and other recreation boats. When a qualified high water event is predicted, the inlets remain closed for about 4-5 hours on average including the duration of the high water and the gates opening and closure times (Mag.Acque-CVN 1997). However, depending on the meteorological conditions determining the tidal event (particularly the intensity and duration of winds and low atmospheric pressure) the gates may be closed much longer, typically 11 hours plus operational time (Rinaldo et al. 2008).

According to the Venice Water Authority (*interview: policy-maker, June 2010*) that oversees the design and the implementation of the works, the mobile barriers are meant

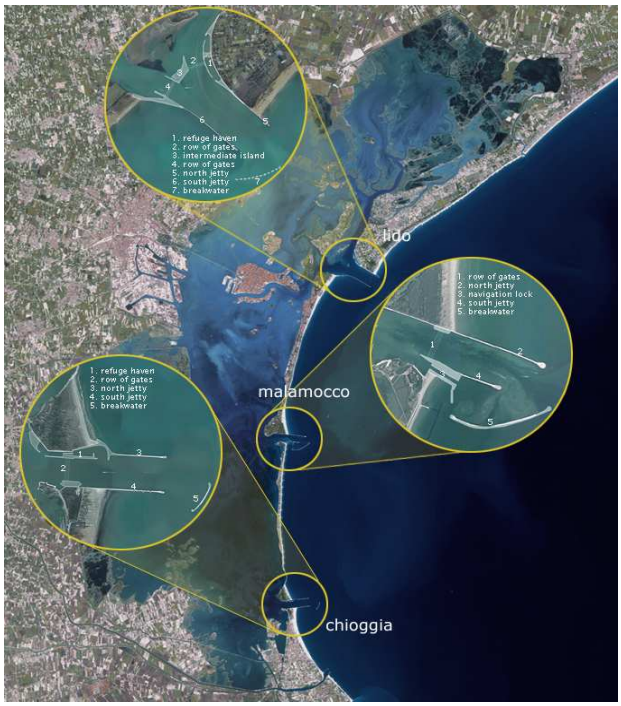
to protect the lagoon from extreme high waters with a tidal level up to 2.20 m above m.s.l. (the worst high water ever registered reached 1.94 m above m.s.l.). Because the inclination of the gates can be changed, the level of protection can be increased from 2.20 m above m.s.l. (with 42 degrees inclination) to maximum 3 meters (with 45 degrees inclination). Proper functioning of the barriers is ensured even in case of an acceleration of sea level rise up to +60 cm above current mean sea level. The barriers, in fact, were designed to withstand +60 cm SLR since the first draft project (so called REA project) in 1989 following the example of the Dutch storm surge barriers (*practitioner, personal communication, September 2010*).

Pirazzoli (1991), however, argues that the barriers would suffice only up to +30 cm SLR and that for higher levels part of Venice would be flooded even when the barriers are in operation. This is because, in case of +50 cm SLR and situations of long-lasting closures due to adverse meteorological conditions, the water level in the lagoon may rise about +18 cm due to possible fluxes of fresh water into the lagoon from precipitation, river run-off and seepage of sea water between the barriers (Pirazzoli & Umgiesser 2003, 2006). On the same line of reasoning, a more recent study of Rinaldo et al. (2008) considering the same parameters of Pirazzoli and Umgiesser suggested that in case of prolonged closures the mobile barriers can effectively protect Venice up to +50 cm rise of sea level without significantly altering the water level in the lagoon. In this study, Rinaldo et al. have also demonstrated that the assumptions in the Pirazzoli and Umgiesser study are too conservative.

Figure 2.8 shows the project and provides some relevant numbers[10]. More than 60% of the works has been completed (2010) and, assuming funding will be timely ensured, the system will be operating in 2014 (CVN 2010). Once in operation, the maintenance costs of the barriers will be about 12 million Euros per year on average, i.e. about 0.25% of the investment, which is 4.9 billion Euros for the barriers only.

[10] For further details about the mobile barriers project see (CVN 2010)

Figure 2.8 Project design of the mobile barrier system to protect Venice from tidal floods (MOSE)



Some numbers of the MOSE system in Venice

4 the number of mobile barriers being constructed at the lagoon inlets (**2** at the Lido inlet, **1** at Malamocco and **1** at Chioggia)

78 the total number of disappearing, oscillating and floating gates, hinged to the inlet bed

18.5 m x 20 m x 3.6 m length, width and thickness of the smallest gate (Lido – Treporti row)

29.6 m x 20 m x 4.5 m length, width and thickness of the largest gate (Malamocco row)

1 lock for large shipping at the Malamocco inlet (**370 m x 48 m x -14 m** length, width and depth) enabling port activities to continue when the gates are in operation

3 small locks (**2** at Chioggia and **1** at Lido-Treporti) to allow the transit of fishing boats and other smaller vessels when the gates are in operation

2 breakwaters (**1** at Chioggia about 522 m long and a peak height of 2.5 m and **1** at Malamocco about 1300 m long and a peak height of from 3 to 4 m)

4-5 hours the average duration of each closure

30 minutes the time required to manoeuvre the gates

4.9 billion euro the total cost of the project

Source: (CVN 2010)

Figure 2.9 Functioning of the floating gates (first 3 figures from the left) and cross-section of the gates and the housing buried in the inlet bottom (on the right)

Source: (CVN 2010)

Additional measures to protect Venice from high waters

To abate the level of the most frequent but not exceptional high waters (those below the safeguarding level requiring closing the gates), two additional sets of measures are being implemented: complementary measures at the lagoon inlets and local defenses in the built areas inside the lagoon. The CVN is responsible for the complementary measures and the local defenses in the lagoon settlements and in some areas of Venice. The Venice Municipality through the company Insula carries out local defense works within the city of Venice and some islands within its municipal domain.

Complementary measures comprise raising and protecting specific sections of the lagoon bed in the inlet channels by constructing sea side breakwaters to the south of the

inlets to reduce wave height by abating winds and enabling navigation. They also aim to increase resistance to the inflow of water thus reducing tidal levels in the lagoon by an average of 3-4 cm (CVN 2010). Works have been completed except for the breakwater at Lido inlet (construction was approved after long discussion in 2010). Preliminary results show that the tidal level in the lagoon is being reduced by about 2 cm (*scientist, personal communication, May 2008*).

The local defense strategy consists of raising lagoon quaysides, embankments and public paved areas as much as possible up to +110 cm above m.s.l. or more. The ultimate aim is to create a basic level such that the gates have to be closed only when the predicted tidal storm surge level is more than 110 cm above m.s.l. Works started in the beginning of the 1990s. The intervention is integrated with the restoration of buildings foundation, bridges and public utilities. So far, about 43% of the planned works for raising public walkways has been completed and nearly 77% of the planned lagoon embankments have been restored (Ufficio di Piano, 2008). It is not possible, however, to raise uniformly the entire lagoon urban areas up to the safeguarding level because there are limits related to the architectonical structure of the historical centers. When sufficient and regular funding will become available, the local defenses in the city of Venice will be completed by 2030.

2.5 On the ability of the measure to protect Venice from high waters under future sea-level rise

The following two sub-sections combine the information previously given in order to answer the question whether the measures being implemented to protect Venice from high waters will suffice under future SLR. As the previous sections, we will use the non-structural vs. structural measures distinction in this section.

2.5.1 Non-structural measures and SLR

The institutional and management system established by the Special Law regime in the Venice lagoon is rather complex. Overlap of responsibility and not sufficient coordination of knowledge and management instruments are major sources of inefficiency (Dente et al. 2001; Musu 2001b; Fletcher & Da Mosto 2004; OECD 2010). Programs for solving problems are almost never fully implemented because of lack of transparency in governability, accountability and legitimacy of the different parties (Musu 2001b). The competition between the governmental authorities in charge of

safeguarding works for national financial resources and the top-down approach to decision-making generated a situation of political friction between local, regional and national authorities. This political friction has led to less than optimal cooperation in the past decades. In particular, the multi-decadal debate concerning whether or not to build the mobile barriers system and the management approach to prevent the environmental degradation of the lagoon, have polarized the scientific, political and social community (Da Mosto et al. 2005). The central government has always been in favor of protecting Venice by means of a movable tidal barrier (MOSE), while the municipal government (the city Council of Venice) has always been very critical with regard to this solution. After many years of disagreement the Comitatone (see Figure 2.5) decided for the construction of MOSE on the basis of the evaluation of the project made by five international experts (Collegio di Esperti di Livello Internazionale 1998).

At present, defense infrastructures are mostly under construction or completed. The local scientific and political communities call for a novel governance system of the lagoon including the management of the barriers. This new regime is expected to coordinate all important sectors and levels of government over a commonly defined territory. Decision-makers should be able to rely on sound knowledge, to be generated by a coordinated and rationalized environmental monitoring system collecting all scientific research. For this purpose, a joint effort of all local, regional and national authorities is required in the coming years. The history of political friction, mistrust and insufficient cooperation does not make it easy to start a process of reform. In 2010, the development of a novel governance regime through a new Special Law has been put in the hands of the Minister for Public Administration and Innovation to coordinate the activities to reform the Special Law for Venice.

It is the integrated action of all safeguarding measures (see Table 2.2) and in particular local defenses, mobile barriers and complementary measures together that will ensure protection of Venice from high waters and SLR. The financing system, however, has not assured yet a full continuity of funds to complete the safeguarding works. In addition, financial resources have been significantly reduced since the works for the mobile barriers started to be funded in 2003 (Ufficio di Piano 2010a). As a consequence, some of the administration's programs are being implemented without a long term guarantee for continuity and coordination, with some activities more ahead than others (see section 2.5.2). Most notably, in the year 2014 the mobile barriers are planned to be operational while the local defenses in Venice will not be completed

before 2030. This implies that large areas of Venice will still be flooded by high waters below the safeguarding level at least until 2030, or it implies that the closing regime will be adjusted accepting more frequent closure of the barriers until local protection up to 1.10 m is ready. This is not necessarily a major obstacle with reference to the port activities and the ecological quality of the lagoon.

Abating water pollution is important in order to prevent environmental degradation due to frequent and prolonged closures of the barriers (more details on this point will be given in section 2.5.2). In this regard, works in the catchment basin (see Table 2.2) are to some extent behind the earlier agreed schedule. This is not due to insufficient resources but because of an intricate system of allocating funds by the Veneto Region (Ufficio di Piano 2010b). Complex planning and decision-making procedures within and across local administrations, and not sufficient inter-institutional cooperation also slow down works to abate pollution within the lagoon basin.

Finally, for the proper management of the mobile barriers reliable tidal forecasts are crucial. To minimize the number of closures, false alarms need to be avoided. Therefore, the tidal forecasts have to be timely and accurate and be made available to the barrier manager (Collegio di Esperti di Livello Internazionale 1998). To forecast high waters, different types of data are required (e.g. river discharge; meteorological data such as winds, atmospheric pressure, precipitation, marine circulation and tide data, etc.). These data are collected by different administrations. According to the Ufficio di Piano (2007), a single data storage and knowledge generation system does not exist and monitoring procedures are not standardized yet. Consequently, data are often not fully comparable and because each agency conducts monitoring programs for relatively short periods and different purposes, there is no data available over a long period of time. Some duplication of data and monitoring stations, and lack of specific information also exists. In addition, institutions are inclined to act as holders of knowledge and are not always prepared to share data and information (Ufficio di Piano 2007). Scientific research on the lagoon environment and safeguarding issues is only partially coordinated and not always sufficiently fine tuned towards safeguarding goals and emerging problems such as climate change (Ufficio di Piano 2007, 2010a).

Against this background, existing government system set up by the Special Law regime is not sufficiently geared towards efficient and effective management of the mobile barriers and of the Venice lagoon as a whole. Building the barrier in itself is not a

guarantee that it will work efficiently and effectively. A well coordinated institutional system would definitely provide a better starting position.

2.5.2 Structural measures and SLR

The preliminary project of the mobile barriers was submitted to environmental impact assessment and reviewed by a committee of international experts (i.e. Collegio di Esperti di Livello Internazionale) established by the President of the Italian Council of Ministers in 1996. The environmental impact assessment and the international committee took sea level rise induced by climate change into account. In particular, in the environmental impact assessment the impacts of the project in terms of frequency of high waters were checked with reference to three SLR scenarios. On the basis of the 1995 IPCC scenarios and other scientific studies conducted by Italian and international scientists[11], the international committee came to the conclusion that the SLR scenarios used in the environmental impact assessment provided sound basis for planning over 50-100 years (Collegio di Esperti di Livello Internazionale 1998 pp. 9-10).

The level of protection from SLR ensured by the mobile barriers (a maximum of +50-60 cm SLR in 2100, see section 2.4.2) is likely to be adequate given current climate change knowledge and the estimated life span of the infrastructure (about 100 years). The level of protection covers the "most likely" scenario, which is somewhere in between +30 and +60 cm in 2100 (see section 2.3). Greater protection from SLR in the project design would be meaningless. In fact, mean sea level higher than +60 cm above present time implies that the barriers would close about 50% or more of the time. Only during low tide they would be open for a few hours. In this situation, the flushing of the lagoon would be greatly reduced. This would transform the lagoon into a more fresh water body and polluting substances would not be removed anymore. So it is likely that when mean sea level rises by 60 cm or more completely new options for the future of the lagoon would have to be considered anyway.

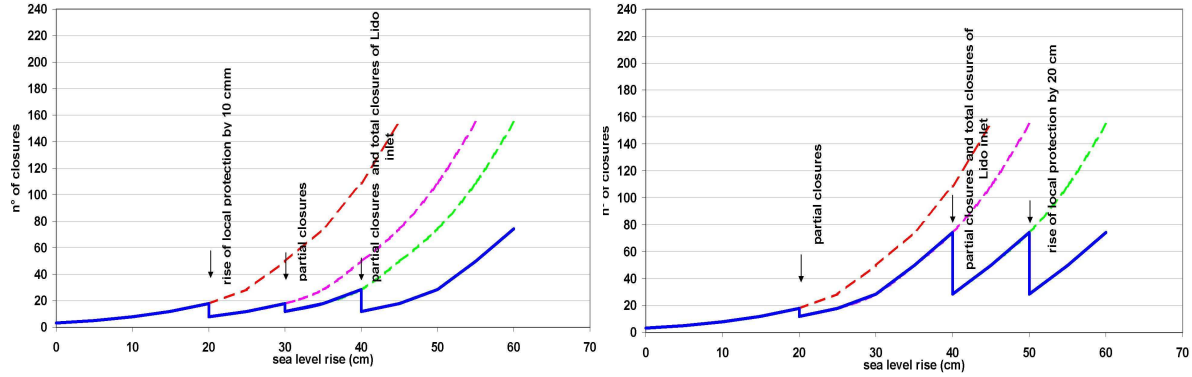
Increased frequency of high waters due to SLR will lead to increasingly frequent closures of the mobile barriers in the coming decades. Local defenses and complementary measures together buy time as they reduce the number of closures per year. Local defenses reduce the urban surface that is flooded by high waters below the safeguarding level. At present time, a tidal peak of +110 cm above m.s.l. floods about

[11] e.g. Blondeaux et al., 1982; 1986; Camuffo, 1993; Cecconi et al., 1998; Marzocchi and Mulargia, 1996; Rusconi, 1993 in Collegio di Esperti di Livello Internazionale, 1998 (see the report for reference)

14% of the city of Venice on average 4 times per year (see Figure 2.4-right). With no local defenses, the same tidal peak would flood the same area about 32 times per year in a SLR scenario of +25 cm by 2100 (see Figure 2.4-right). To limit the flooded surface, the safeguarding level will have to be set lower than +110 cm at least until the completion of the local defenses, thus increasing the closures. With local defenses in place and the current safeguarding level, in a SLR scenario of +25 cm by 2100 only those small districts that cannot be raised up to +110 cm would be flooded (about 1% of the city, including some valuable areas such as S. March square, however). The complementary measures will further help reducing the urban surface that is flooded by high waters below the safeguarding level by abating tidal levels of about 2-3 cm (see section 2.4.2). The small number of centimeters suggests that this effect is not very important. However, this effect should be compared with the cost of heightening the local defenses in Venice by a similar level. In addition to these measures, it is possible to adjust the management strategy of the barriers so as to reduce the number of full closures as sea level rises. Two possible management strategies of the barriers according to different sea level rise scenarios are illustrated in Figure 2.10. In both cases initially the number of full closures will increase as sea level will rise. However, because the barriers are made up of independent gates, it is possible to introduce partial closures in the management (e.g. closure of one inlet at a time, or partial closure of each inlet). By using partial closures the water level in the lagoon can be reduced by 10-20 cm or even more (Scotti 2010). Then, to further bring down the number of full closures in case of eustatic scenarios above +20 cm SLR, it is possible to increase the level of the local defenses. This extremely costly solution can, however, wait until +50 cm SLR (Figure 2.10-right). Up to +50 cm SLR the proper functioning of the barriers is, in fact, ensured (Rinaldo et al. 2008) and thanks to the partial closures the number of full closures would remain limited. This would reduce the impacts on the ecosystems (see following paragraphs) and on the functioning of the port (because using navigation locks is much slower than direct transit through the inlets). This approach gives time to either find the resources or to test innovative solutions to raise the historical centers (e.g. injection of brackish water in the ground to raise the city or use hydraulic ram to raise single buildings[12]). It also gives at least 50 years to plan a novel defense strategy beyond the +50 cm SLR threshold.

[12] For more details about injection of brackish water in the ground see (Comerlati et al. 2004; Castelletto et al. 2008). We believe this idea needs to be carefully investigated, as the Venice lagoon underground could not be sufficiently stable. Moreover, if feasible, a precautionary approach is wise to be recommended. Testing the solution and monitoring the results in much less valuable areas

Figure 2.10 Different management strategies for the mobile barriers in Venice according to various SLR scenarios



Source: (Scotti 2010)

With more frequent closures the ecological system of the lagoon will increasingly be affected, although the impact is difficult to quantify (Collegio di Esperti di Livello Internazionale 1998; Ministero dell'Ambiente 1998; Pirazzoli & Umgiesser 2003; Italia Nostra 2009, interviews: public officers, scientist, practitioners, April 2010). However, as long-lasting closures mainly occur in winter when biological activity is relatively low, the ecological effects of separating the lagoon from the sea are considered minor (Mag.Acque-CVN 1997; Collegio di Esperti di Livello Internazionale 1998). According to Gacic et al. (2002) the rate of water flow through the lagoon inlets is such that leaving the barriers open for a few hours should rinse out most of the pollutants that accumulate inside. Moreover, by increasing the water depth in the lagoon and water exchange at the inlets, SLR will increase the dilution of pollutants and their expulsion at sea (Cecconi 1997; Ramieri 2000). In addition to that, the lagoon water quality has improved in the last ten years, even though water quality objectives have not been fully achieved yet (Ufficio di Piano 2008a, 2010a). Finally, the fact that the barriers allow partial closures and not all high waters will require the lagoon to be completely separated from the sea will ensure maintaining water exchange in the long term. Partial closures may also be used to force water circulation into boundary areas with long residence time so as to wash them out, thus improving water quality (Rosatti et al. 2002). This use of the barriers needs to be experimented because forcing water circulation may alter lagoon hydrodynamics and the network of tidal canals (*interview: local agency officer, April 2010*).

before doing it in the Venice historical center seems reasonable. About raising up single buildings by using hydraulic ram, an experiment will probably soon be done with the San Moisé church in Venice. If successful, it could be implemented on large scale in the city of Venice.

Against this background, we conclude that the integrated system of infrastructure (mobile barriers, complementary measures and local defenses) that is being built is in principle adequate to protect Venice lagoon urban centers for about the next 100 years given the various SLR scenarios, the expected frequency of high waters and the related expected number of barriers closures.

2.6 Discussion

In the following we discuss the findings of this paper following the non-structural vs. structural measures structure.

Looking at the non-structural measures, reform of existing institutions would greatly increase efficiency in the Venice system. A comprehensive assessment of the achievement of the objectives, and the environmental, economic and social impacts of these nearly 40 years of Special Law regime would be a strong basis upon which designing the path for a sustainable development of the region in the next 30-40 years. To our knowledge, such a comprehensive assessment has never been done. Particularly, social studies regarding impacts of the Special Law policy are missing. Most studies focus on environmental and economic impacts of specific infrastructures and environmental quality of the lagoon.

Moving from the results of such a study and the expectation of the stakeholders, the institutional reform is, according to our perspective, twofold: on the one hand, the management and maintenance of the mobile barriers; on the other hand, the governance of the Venice lagoon as a whole from an environmental, economic and social perspective. The “book of the rules and of the exceptions to the rules” (*quote from one of the interviewees, March 2010*) for the management of the barrier closures could be designed according to a hierarchy of safeguarding goals. Involving all interested parties would ensure trade-offs to be carefully balanced (e.g. protection from high waters vs. environmental goals vs. economic interests). For the management of the barriers, it would be also important to integrate the existing tidal forecast center of the Venice Municipality with that of the Venice Water Authority. This could make forecasting more efficient. Reliability of tidal forecast could also be improved by research on the effects of climate change on frequency, height and intensity of high waters. Such a single agency needs to have prompt access to all required data. For this purpose, the coordination of monitoring systems and standardization of data gathering and

processing procedures is an important issue for next few years. Updated scientific knowledge about climate change and relative impacts on the lagoon is also fundamental for the management of the barriers (as it would help generating more accurate tidal forecasts) and the whole lagoon in the long-term. The attention of national and local policy-makers seems to move in this direction. In the year 2010, in fact, a range of initiatives has been taken to develop future sea-level rise scenarios for Venice with the involvement of Italian and international scientists that will help to clarify and improve climate knowledge relevant for the region. The Venice Water Authority, in addition, has started to explore adaptation measures for its water management works based on improved knowledge on climate change and sea-level rise.

On a larger scale, a renewal of the governance system to be designed through a new Special Law would help creating the institutional setting required for an efficient management of the whole lagoon, its catchment basin and the near-shore sea. By clearly defining administrations' responsibility, planning and management instruments, mechanisms for funding supply and allocation, and assessment and evaluation procedures, the institutional system may be simplified and therefore become more efficient. Including in the new Special Law mechanisms to revise rules and procedures, for example, could allow timely adjustment of the safeguarding strategy according to new climate knowledge. This is crucial given the uncertainty related to SLR projections and other socio-economic developments in the long term. Consultation and direct involvement of all stakeholders (i.e. policy makers, scientists, private sectors and civil society) since the early stages of the process could ensure a wide consensus, required for such a reform to take place.

Another important aspect related to the current institutional system is financing. Ensuring timely and sufficient funding for the completion of all safeguarding works (local defenses, water pollution abatement measures, and mobile barriers) is the *condicio sine qua non* for allowing an efficient protection of the lagoon urban centers from high waters and sea-level rise. It seems particularly important to complete the local defenses in Venice as soon as possible before 2030. The barriers alone (most likely in operation in the years 2014), in fact, will not ensure protection from the most frequent high waters unless they will be closed more often. These extra closures, if planned until the local defense will be finished, would add up to the regular closures due to exceptional and extreme high waters, which will also be more and more frequent in the coming decades. The number of closures would then significantly increase generating

consequences for the ecosystems that are difficult to envisage. Once the safeguarding works will be completed as foreseen by the Special Law regime, a question frequently asked about financial resources is: where resources for the maintenance of all safeguarding works should come from? Maintenance costs of the barriers are high. The barrier on the Thames in London and that in Rotterdam were built with national funds. They are State owned and the State itself pays the maintenance. Following these two examples and considering the big investment of the Italian government and the high maintenance costs, it is not unlikely that the State would ensure the proper functioning of the barriers by providing the finances required for their maintenance. However, the maintenance of other safeguarding investments such as the local defenses will probably be financed by the local authorities. The State financed the extraordinary safeguarding intervention because of decades of lack of maintenance. Ensuring the safeguarding works to last in the future is probably part of the duties of the municipality itself, as it is in all cities in the world. A balance needs to be found, however, as Venice is a city where deterioration of buildings and infrastructure is accelerated by the fact that they lay on the water and they are very old.

With reference to the structural measures for protecting Venice from high waters and sea-level rise, we want to focus our discussion on the future of the investment. The integrated system of hydraulic defense infrastructure being built gives time (probably about 50 years) to plan further adaptation actions according to experience and new scientific knowledge. However, we think it is essential to also look for solutions beyond 2100. Sea level rise beyond +50-60 cm would require developing a large scale strategy for the whole coastal region. Eventually, drastic options for the lagoon, including a full closure, could become unavoidable. In this regard, it would be practical to consider the long term future while implementing present priorities. The discussion may regard technical aspects such as using parts of the investment (the hard structures that have shaped the inlets, such as the jetties, the breakwaters, the foundation structures, the navigation locks, the havens, etc.) as the basis for additional works for the future. Starting this discussion now that the barriers are still under construction would have the advantage of allowing implementing some adjustments if needed in this phase. Any change in the present construction, however, would be very expensive and therefore only possible if critical risks or major opportunities are identified.

Finally, as soon as the mobile barriers will be in operation, steady monitoring the impacts of the closures on the lagoon ecosystems and on water quality would facilitate

prompt adjustment of the defense strategy in the short-midterm, if needed. Particularly, careful experimentation and monitoring of the effects of extra closures to force water circulation in peripheral areas of the lagoon may prevent serious negative impacts on the lagoon ecosystems to occur. An adaptive management approach (Holling 1978; Walters 1986; Schreiber et al. 2004) is here recommended to prevent irreversible changes in the ecosystems. In addition, because extra closures influence the barriers management strategy, it is important to plan these closures in consultation with all the relevant parties (port authority, fishermen, etc.).

2.7 Conclusions

This paper describes the measures carried out to protect Venice from high waters under the so called Special Law regime and reflects on their ability to anticipate sea-level rise induced by climate change. First, it was made plausible that a scenario with +50 cm SLR expected by 2100 in the Venice region would have a significant impact in terms of increased frequency of high waters in Venice (tens of times every year). The uncertainty related to this finding was also highlighted. Second, it was shown that in Venice different infrastructural works (structural measures, i.e. storm surge mobile barriers, local defenses, complementary measures) are being carried out to protect the lagoon urban centers from high waters (i.e. tidal floods) within the so called Special Law regime (non-structural measures, i.e. laws, regulations, public and private organizations, planning instruments) since the 1970s. Third, it was pointed out that the ability of these measures to protect Venice from accelerated sea-level rise will depend on timely completion of all infrastructures for which a steady flux of financial resources is needed. It will also critically depend on the effective management of the barriers and the implementation of a novel governance regime for the whole lagoon designed on a climate change perspective.

The results of the present study are based on a number of data collection strategies and information sources. Reflecting on the fact that two of the authors participated in meetings of the Ufficio di Piano, it is important to report both advantages and disadvantages. Although the involvement may have introduced a bias towards either favoring or disfavoring the outcome, this was outweighed by the advantages. One of the advantages was that the participatory observation gave the unique opportunity to gain a thorough understanding of the Venice formal and informal system. In addition, participatory observation facilitated access to different interviewees. The knowledge

gained with participatory observation was supplemented with documental information and interviews. The policy documents allowed for a look into the (planned) future, whilst the legal documents helped identification of legal responsibilities. The interviewees were chosen such that different perspectives on the safeguarding of Venice were represented and indeed different opinions were expressed. The use of peer reviewed scientific articles helped distinguishing between local preconception and scientific knowledge, particularly about climate change and the mobile barriers. Newspaper articles were also included, because these ensured that the researchers would not miss issues relevant to the general public and the public's perception of Venice governance and management issues. In addition, because the Ufficio di Piano is a technical advisory committee with a majority of independent members from Italy and Europe that gained information from all different public and private organizations in charge of safeguarding Venice lagoon, our perspective goes beyond the policy dominated views of the administrations and the government anyway.

Our research has focused on SLR and its impacts in terms of high waters in Venice. The Special Law regime, however, funds a number of different measures (see Table 2.2) and the Venice lagoon can be affected by global warming consequences other than SLR. For example, increase of water temperature and changes in precipitation patterns are likely to affect the hydrological conditions and biogeochemical processes, lagoon water quality and salinity and therefore ecosystem functioning and biodiversity. A comprehensive assessment of the ability of all safeguarding measures to address different climate change impacts was beyond the scope of our analysis. Indeed, we think it is required as baseline for adjusting the defense strategy in the long term.

Climate change is a global challenge and the Venice lagoon is not an isolated example. Complex and bureaucratic governance arrangements are widespread especially in coastal lagoon areas and estuarine system. This makes coastal systems increasingly vulnerable to environmental change, like climate change may induce. The example of Venice shows that high level of technical and scientific knowledge and building infrastructure alone does not necessarily lead to the expected level of safety of the coast. Adaptation requires both structural measures such as soft and hard coastal protection works and non-structural measures such as institutional reforms to deal with increasing uncertainty and risk related to climate change. Building infrastructures seems relatively easy when resources are available. Setting up of adequate governance arrangements to manage these new systems does not always receive adequate attention. Governance of

adaptation is a relatively new field in the social sciences that requires in depth understanding of cultural, social, political and environmental contexts. Above all it represents a new priority for policy makers, requiring a change in attitude to the political vision. Improvements can be obtained with a greater integration and coordination of institutions, knowledge, planning and management systems at all governmental levels. In particular, the need to strengthen local long-term planning mechanisms and establish cross-scalar institutions to support complex decisions is recognized when dealing with hard coastal defense infrastructure with long life span. A wide spatial vision at natural basin level is also important. It implies cross-sector partnership at different administrative level and a share of responsibilities. Finally, adaptation is financial demanding in coastal areas, therefore mechanism to make financial resources available are needed, such as reformulating scale of priorities and ensuring resources to existing programs that support adaptation rather than making new programs.

The above suggests that decades of studies funded by the Special Law regime generated technical and scientific knowledge and allowed building infrastructure that could make Venice one of the foremost regions adapting to climate change. However, if not properly maintained and managed and without ensuring the completion of all works, the whole investment may fail to achieve the original goals. Designing the mobile barriers closure regime and a novel governance system for the whole lagoon would be first best. Reforming the current Special Law for Venice regime offers an opportunity to develop such a new regime with all relevant parties. Taking a climate change perspective in developing the new institutional system would then ensure long term protection from climate related risks. Concluding, the integrated system of mobile barriers, local defenses and complementary measures being built at the inlets and in the urban centers can be considered adequate to protect the Venice lagoon for the next 100 years, given various SLR scenarios and expected high waters on the condition that the governance structure allows for timely completion of all infrastructure as well as adequate management and maintenance including the allocation of funding sources and removal of administrative barriers.

3 Assessing adaptive capacity of institutions to climate change. A comparison of the Venice lagoon and the Dutch Wadden Sea

Abstract

In this study we assess the adaptive capacity of relevant institutions for ecosystems and environmental management in two complex systems, the Venice Lagoon and the Dutch Wadden Sea.

A new tool called the Adaptive Capacity Wheel (ACW) is used to diagnose strengths and weaknesses in the institutional systems in these two areas. The ACW identifies six dimensions that are relevant for the adaptive capacity of a society, according to the literature on climate adaptation and governance. They are variety, learning capacity, room for autonomous change, leadership, availability of resources, and fair governance. Then, we compare the two cases drawing attention to the physical and institutional similarities and differences that could explain the level of adaptive capacity we found.

In this study, the physical and economic characteristics of the two regions proved to be quite similar, while the institutional system was very different. These two different governance systems, however, lead to a similar low level of adaptive capacity. In the Wadden, decisions are difficult to make because of lack of authority and leadership. In Venice, lack of cooperation and accountability limit learning. We conclude that in both cases there is a lot to be improved and that the two regions can learn from each other.

Key words: adaptive capacity, governance, institutions, ecosystems, water, climate change, Venice lagoon, Wadden Sea

Chapter to be published as:

Munaretto S. and Klostermann J.E.M. Assessing adaptive capacity of institutions to climate change. A comparative case study of the Dutch Wadden Sea and the Venice lagoon (in review for publication by Climate Law)

S. Munaretto conducted the analysis and wrote the sessions on the Venice case; J. Klostermann did that on the Wadden case. Introduction, comparison and discussion and conclusions are a joint effort of the two authors.

3.1 Introduction: climate change, adaptation and human institutions

Coastal systems are especially vulnerable to climate change, according to the IPCC report of 2007 (IPCC 2007a). Some of the expected impacts include: an accelerated rise in sea level, which may lead to coastal flooding and inundation, erosion and ecosystem losses; a rise in sea temperature with an effect on ecosystems; a change in precipitation and runoff. The IPCC report also concludes that adaptation to climate change will be necessary to avoid impacts that are already unavoidable due to past emissions of greenhouse gases (IPCC 2007a).

Governance has become a key concept in policy research to respond to the inherent uncertainties in human and natural systems (Armitage et al. 2007; Young 2007; Pahl-Wostl 2009; Biermann et al. 2010). One of the main characteristics of governance is the transition from traditional government (bureaucratic, centralized top-down steering) to new forms of horizontal and vertical decision-making that are less hierarchical and more inclusive, decentralized and flexible (Biermann et al. 2010). The involvement of private actors and citizens in public decision-making is also important in governance processes as environmental policy decisions are increasingly a question of negotiation and agreement among stakeholders and less a matter of appropriate expertise (Brunner et al. 2005). In order to improve the way society deals with human-environment relations, major institutional reforms can be required (Young 2007; Pahl-Wostl 2009). This is a challenging task because institutions are traditionally conservative (Gupta et al. 2010) and can inhibit timely decisions.

We define institutions as: “systems of rules, decision-making procedures, and programs that give rise to social practices, assign roles to the participants in these practices, and guide interactions among the occupants of the relevant roles” (IDGEC 1999 p. 14). This is a broad definition that includes formal institutions such as laws, but also informal rules such as the ways in which people use formal institutions and the social conventions that exist in a region or among a group of people. Institutions provide stability and predictability, without which cooperation and coordination within our human society would be impossible (Scharpf 1997). Institutions tend to be resistant to change, because they generally are the result of a long discussion and negotiation process; once something is agreed and implemented in social routines, it is not appreciated to restart the debate. At the same time, when changes occur within society or nature, institutions need to be adapted to foster adequate societal responses. The same

agency that sustains the reproduction of structures also makes possible their transformation (Sewell Jr 1992).

In relation to climate change, it is critical that institutions allow society to adapt to the environmental changes fast enough. The "natural" speed with which society adapts its institutions is possibly enough to keep up, but it is also possible that we need an extra effort. And if we do need an extra effort, we should know which institutions are the most inhibitive and should be redesigned as a matter of priority. To assess the adaptive capacity provided by a society's institutions, a method called the "Adaptive Capacity Wheel" was designed by Joyeeta Gupta et al. (2010). In this paper we use the Adaptive Capacity Wheel (ACW) to assess if the existing institutions in two coastal areas, i.e. the Venice lagoon and the Dutch Wadden Sea (also referred in this paper as Wadden Sea or Wadden), enhance or limit the adaptive capacity of society in that region. Results of applying the ACW are then used to compare the two cases in a structured way to further explain adaptive capacity of institutions. Our goal is to answer the following four research questions:

1. *Do relevant institutions for ecosystems and environmental management support adaptive capacity to climate change in the Venice lagoon and the Wadden Sea?*
2. *In what physical and institutional aspects are the two regions different and in what aspects are they similar?*
3. *Do different institutions in the two regions produce similar or different outcomes in terms of adaptive capacity to climate change?*
4. *What can these regions learn from each other to improve adaptive capacity to climate change?*

The next section illustrates our methodology (section 3.2); sections 3.3 and 3.4 present the results of the ACW applied to the two case studies; in section 3.5 we show the results of the comparison. Finally, section 3.6 draws some conclusions and recommendations for both regions.

3.2 Methodological approach

Our method contained the following steps: a description was made of the two cases Venice and Wadden, and the Adaptive Capacity Wheel was applied to them; next, the descriptions as well as the results of the Adaptive Capacity Wheel were compared; and finally, conclusions were drawn on possibilities for mutual learning between Venice and Wadden, and for the adaptive capacity of delta regions in general. Below we explain these steps in more detail.

As was announced in section 3.1, in this research we focus on institutions. We define adaptive capacity related to institutions as "the inherent characteristics of institutions that empower social actors to respond to short and long-term impacts either through planned measures or through allowing and encouraging creative responses from society both ex ante and ex post" (Gupta et al. 2010). Adaptive capacity encompasses: the characteristics of institutions (formal and informal; rules, norms, and beliefs) that enable society (individuals, organizations, and networks) to cope with climate change; and the degree to which such institutions allow and encourage actors to change these institutions to cope with climate change.

For both cases, data were collected though document analysis and interviews. For the Venice case study, key aspects of the environmental, social, and governance system were described on the basis of scientific literature, policy documents, and evaluation studies[13]. Interviews in Venice involved sixteen stakeholders and were conducted between March and June 2010. These are high level policy-makers, scientists and practitioners having many years (in most cases more than a decade) of working experience in local public and private organizations. They all have engaged in the discussion or in actions for the safeguarding of Venice, water, ecosystems and environmental management and climate change adaptation. The knowledge about the governance system of the Venice lagoon that the first author gained in the past six years working on the safeguarding of Venice[14] helped choosing the interviewees so as to have broad opinion represented. The present status of the Wadden Sea is described based on

[13] (Sestini 1992; Amorosino 1996, 2002; Cecconi 1996, 1997; Mag.Acque-CVN 1997; Torricelli et al. 1997; Bevilacqua 1998; Collegio di Esperti di Livello Internazionale 1998; Ramieri 2000; Ravera 2000; Musu 2001a; Mag.Acque-Thetis 2006a; Cossarini et al. 2008; Ufficio di Piano 2008a, 2010a; Da Mosto 2009).

[14] Since 2005 the first author has been member of the Technical Secretariat of the Ufficio di Piano committee which was appointed to advice the national government on measures and priorities for the safeguarding of Venice. The Ufficio di Piano is a mixed technical committee made up on national and international scientists and national and local policy-makers.

scientific reviews and policy documents[15]. In addition, semi-structured interviews were held with eleven respondents representing stakeholders of different nature, leisure, and governmental organizations. For the selection of respondents, firstly a list was made of the organizations most involved in the management of nature and environment in the Wadden; of these organizations, the people were selected with the most knowledge of climate change. Most respondents had been involved in Wadden policy and management for many years. In both case studies, respondents requested anonymity.

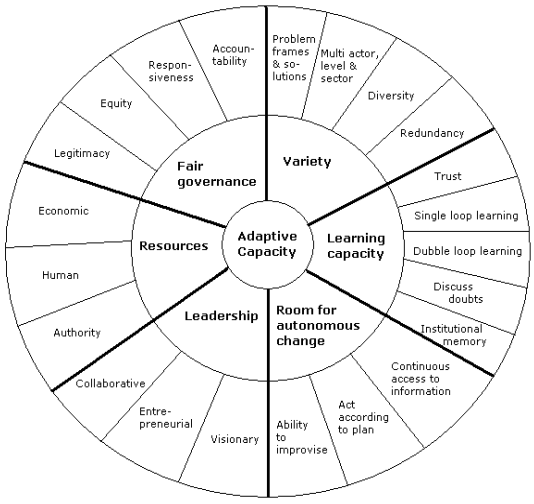
To answer the first research question we applied the ACW (see Figure 3.1) to each of the two case studies. We chose to use the ACW framework because it promises to address all aspects relevant to adapting to climate change, and it allows comparing case studies in a structured way. Grounded on a vast literature on governance and institutions, the 22 criteria offer the opportunity to look into the institutional system of a selected case from different perspectives, thus reducing possible biases. The criteria are divided over 6 dimensions, which we will briefly explain here; for a more thorough underpinning of the dimensions and criteria we refer to the methodological explanation in Gupta et al. (2010). Three of the dimensions refer to the inherent flexibility of institutions: Variety, Learning Capacity and Room for Autonomous Change. Variety is considered important for being able to react to different kinds of impact of climate change, because these impacts are largely unpredictable. Variety can be improved, for example, by involving different kinds of social actors in decision making processes. Similarly, Learning Capacity is needed for developing new responses to climate change impacts, and this involves both single loop learning (learning how to do things better) and double loop learning (learning how to do better things). Room for Autonomous Change is needed because top-down responses can be too slow and generally lack detailed local knowledge. Therefore, the ACW considers it better to make use of the self-organizing capacity of local organizations as much as possible. The three other dimensions of the ACW refer to a number of more classic, more widely accepted criteria for effective governance processes: Leadership, Resources and Fair Governance. Leadership and Resources are needed in every change process, and climate change will be no different. The dimension of Fair Governance is similar to notions of "good governance" (Botchway 2001), however, the authors of the ACW method gave it a slightly different name to indicate that efficiency was not part of their dimension of Fair

[15] (Meijer et al. 2004; VROM 2007; Heldoorn 2008; LNV 2008; Dijk & Folmer 2009; Hartman & Roo 2009; Herman et al. 2009; Kabat et al. 2009; Klostermann et al. 2009; Speelman et al. 2009).

Governance. By giving scores between +2 and -2, it is possible to present aggregated scores for each dimension, and an aggregated overall score of adaptive capacity for a case study. Each dimension is scored by calculating the mean of the scores assigned to the criteria of that dimension; the overall score is also the mean of the dimensions' scores (see the scoring scheme in Figure 3.1).

The transcriptions of the interviews were analyzed according to the dimensions of the ACW and interpreted in terms of adaptive capacity to climate change. The scoring process took place in three rounds. First the researcher assigned scores, then the results were discussed between the authors of this study, finally the results were discussed either with the respondents (in the Wadden case) or with one researcher and two practitioners knowledgeable about the governance system (in the Venice case).

Figure 3.1 The adaptive capacity wheel and scooring scheme



Effect of institution on adaptive capacity	Score	Aggregated scores for dimensions and adaptive capacity as a whole
Positive effect	2	1,01 to 2,00
Slightly positive effect	1	0,01 to 1,00
Neutral or no effect	0	0
Slightly negative effect	-1	-0,01 to -1,00
Negative effect	-2	-1,01 to -2,00

Source: (Gupta et al. 2010)

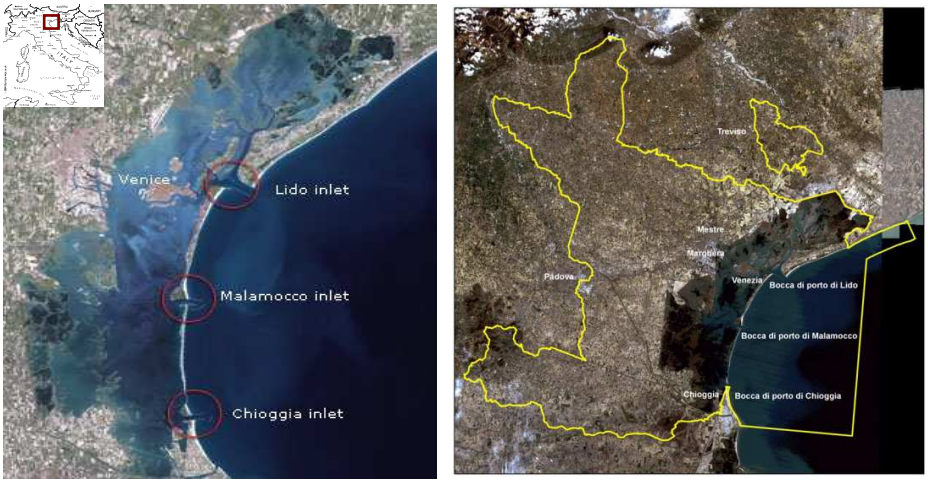
The second research question is addressed by comparing the descriptions of the two individual cases so as to identify similarities and differences between the two regions. Institutional differences then are interpreted together with similarities to explain the different/similar outcomes in terms of the adaptive capacity of each region. By doing so, we answered the third research question. We, finally, answered the fourth research question by looking at the performance of the two regions in each dimension of the

ACW and linking it to the local institutions. In this way we identified those institutions that help to generate adaptive capacity and therefore may be recommended for adoption.

3.3 Case study 1: Venice lagoon

Located in northeast Italy, the Venice lagoon is the largest coastal lagoon in the Mediterranean region (550 km^2). It is a shallow water basin receiving fresh water from a catchment basin of about 2,000 km^2 and exchanging water with the sea through three inlets (see Figure 3.2).

Figure 3.2 The Venice lagoon (left side) and the Venice lagoon, its catchment basin and the facing sea for planning purposes (right side)



Source: left figure adapted from (CVN 2010)*; right figure from* (Regione del Veneto 1999)

Typical coastal environments (dunes, beaches), wetland habitats (salt marshes, mudflats, and shallows), and brackish and fresh water environments (reeds) make up the lagoon's ecosystems (Torricelli et al. 1997; Ravera 2000). Islands, reclaimed land, and banks represent about eight per cent of the lagoon's surface. At the heart of the lagoon is the city of Venice which, with the lagoon, has been a UNESCO World Heritage site since 1987.

The interaction of human and natural dynamics has profoundly shaped the lagoon over the centuries (Ravera 2000; Mag.Acque-Thetis 2006a; Rinaldo 2009). At present, sea-level rise, erosion and subsidence are turning the lagoon into a marine environment, deteriorating typical habitat and increasing the frequency of flooding (the so called "high waters", i.e. a temporary rise in the sea level, flooding the lagoon's urban centers for a few hours, 10 to 15 times a year, mostly in winter).

The resident population in the lagoon has been declining and aging for more than 50 years and the trend seems difficult to invert (Musu 2001a; Da Mosto 2009). In 2010 the lagoon urban centers counted not more than 90,000 inhabitants down from 170,000 in the 1950s.

With more than 20 million tourist presences every year, the tourism sector is the main source of income of the Venice area (Musu 2001a). Other economic activities include the expanding commercial and cruise port and the clam fishing sector. The petrochemical production no longer has a leading role in the economy of the region. After the cleaning up of the abandoned sites logistics for the port will be the main destination of the industrial area.

3.3.1 Expected impacts of climate change

Climate change is likely to exacerbate the existing problems in the Venice lagoon, threatening its existence (Sestini 1992; Cecconi 1996, 1997; Mag.Acque-CVN 1997; Ramieri 2000; Mag.Acque-Thetis 2006a). In particular, sea-level rise is likely to have a number of impacts on the human and natural environments. The major expected impact is the increase in number of high waters which would accelerate urban degradation and increase loss of economic assets and citizen discomfort (Cecconi 1997; Mag.Acque-CVN 1997; Mag.Acque-Thetis 2006a). Another important impact is the submersion of low-lying areas and the consequent loss of natural habitats and land for human activities (Ramieri 2000). A higher sea level would also mean greater water depth and water exchange which would have four different consequences: intensification of erosion of typical lagoon structures due to increased mean height of wind-generated waves; alteration of biogeochemical reactions due to reduced oxygenation of deep water; greater dilution of pollutants and vivification of the lagoon; increase of the lagoon's water salinity and change in the lagoon's water temperature (Mag.Acque-CVN 1997; Ramieri 2000; Mag.Acque-Thetis 2006a). Change in water temperature and salinity is likely to affect water quality, primary production, biodiversity distribution and composition, and biogeochemical processes (Mag.Acque-CVN 1997; Mag.Acque-Thetis 2006a; Cossarini et al. 2008). Finally, modification of precipitation patterns is likely to change seasonal water, pollution, and sediment load from the catchment basin, making it higher in winter and lower in summer than at present (Cossarini et al. 2008).

3.3.2 Governance arrangements

The governmental system in Italy is hierarchically structured with four vertical levels of government: state, regions, provinces, and municipalities. Regions have autonomous decision-making power in many government spheres, including water, ecosystems, and environmental management. The Venice lagoon is subsumed in its entirety by the Veneto region.

Since 1973 a framework of national laws and ministerial decrees known as "the Special Law for Venice" has established goals, instruments, and governmental responsibility for the safeguarding of Venice (Amorosino 1996, 2002; Bevilacqua 1998). It also has allocated ten billion Euros for this purpose (Ufficio di Piano 2010a). An Inter-ministerial Coordinating Committee takes decisions about major safeguarding works and fund allocation. National, regional, and local authorities implement safeguarding measures. The Ministry of Infrastructure, through its local agency (the Venice Water Authority) and its private concessionaire (the Consorzio Venezia Nuova - CVN), is in charge of the physical and environmental protection of the lagoon and the littorals. The Venice Water Authority is also in charge of hydraulic security and water management in the lagoon basin. The Veneto Region is in charge of abating water pollution in the catchment basin, which includes 108 municipalities. The Venice and Chioggia municipalities are in charge of restoring urban infrastructures, building local defenses, maintaining the historical, monumental, and architectural heritage, and supporting the socio-economic sector. Each authority implements the safeguarding measures through its own plan of measures within its administrative boundaries. Inter-institutional agreements are used by the administrations to carry out works in cooperation (e.g. the inter-institutional agreement to renovate urban infrastructures, shafts, and utilities).

Among the safeguarding measures, the CVN is building storm-surge mobile barriers (the MOSE system) at the inlets, local defenses (raising city pavements and lagoon banks) in the lagoon's urban centers, and coastal defense infrastructure at the littorals (for details see CVN 2010). Nature protection is carried out mainly through reconstruction of the lagoon's morphological structures and reconstruction of habitats (see CVN 2010).

A high number of non-governmental actors also actively contribute to the socio-economic life of the Venice lagoon. Most of them are commercial actors and artisans directly or indirectly related to the tourism sector. In addition, dozens of public and

private associations, foundations, and institutes operate in the field of restoration and valorization of the city of Venice, including a UNESCO office in Venice. Scientific knowledge is produced by two universities and by public research institutes and private consultancies. Nature conservation is supported by a number of environmental NGOs since the 1960s (e.g. Italia Nostra and WWF) and citizen's groups. The presence of industry also brings into the picture labor unions, industrial associations, and the port authority. The clam-fishing sector is represented by a recently established consortium for clam farming.

Thanks to the implementation of the safeguarding measures, the state of the environment has improved, although water-quality objectives have not been fully achieved (Ufficio di Piano 2008a). At present, there is a conviction among some policymakers that safeguarding needs have changed. New priorities include the maintenance of the hydraulic infrastructure and the historical heritage. Moreover, the socio-economic development of the Venice area requires a redevelopment of the industrial sector and an increase in commercial port activity. These changes are called for by a revision of the Special Law.

3.3.3 Results of applying the ACW to the Venice lagoon case

The application of the ACW to the Venice case study is presented in Figure 3.3. Table 3.1 provides the key findings of the analysis which are discussed in the following paragraphs.

Variety

A number of public authorities, goal-oriented public-private and private actors pursuing water, environmental, and ecosystems management goals contribute to generate problem frames and ideas. Solutions are mainly sought in hard infrastructure, and few other solutions are developed.

Sea-level rise was considered in the design the storm surge barriers (which can stand +60 cm sea-level rise expected by 2100), the coastal defenses and the morphological restoration measures. Spatial and sectoral planning instruments have only recently started to take climate change into account. An adaptation strategy for the whole lagoon is not discussed by local governmental agencies at present. Only the Venice Water Authority has started to explore adaptation measures for its water management works based on improved knowledge on climate change and sea-level rise.

Learning Capacity

A high number of organizations (we counted nine) has developed scientific and technical knowledge for the development of safeguarding infrastructure and the management of the lagoon. Knowledge about climate change is fast improving.

The long debate about the management of the lagoon and the future of Venice has eroded trust among local actors, generated lack of confidence in the scientific knowledge and made it difficult to discuss doubts constructively. Not all knowledge is shared among local actors or communicated to the public. All these are limiting factors to improve double loop learning, i.e. the possibility to question values and beliefs upon which management strategies are based.

Room for Autonomous Change

Venetians are well adapted to flooding thanks to a number of services provided by the local authority such as raised public walkways on the main streets in the city and a daily tidal forecast bulletin communicated via a free cell phone SMS service and posters throughout the city. Citizens also developed their own strategies such as placing barriers on the front door, using pumps, making valuable belongings easy to remove, wearing boots.

Leadership

Local actors call for a new Special Law for Venice, establishing a single steering authority for the management of the lagoon, the catchment basin and the near-shore sea. Each local governmental agency wants to lead this new authority. Appointing and legitimating the leadership of this authority and building consensus on the objectives of the new Special Law seems difficult due to the lack of trust among public actors. Climate change has not entered the discussion about the new Special Law up to now and governmental agencies conduct climate and adaptation studies separately.

Coordination at vertical and horizontal governmental level of the many spatial and sectoral planning instruments is inadequate.

Resources

The Italian government has allocated 10.2 billion Euros for the safeguarding of Venice of which about one third have been invested in infrastructural works that will protect the lagoon and the city from sea-level rise. The effectiveness of the whole safeguarding

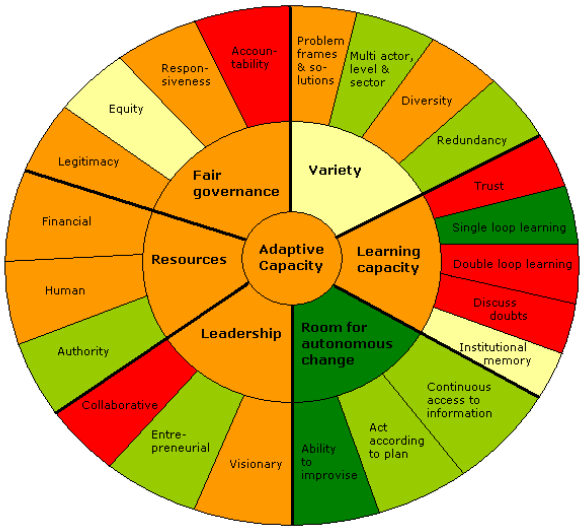
investment depends on the ability of institutions to guarantee continuity of resources to complete all planned measures and to do the maintenance in the coming years.

Apart from the Special Law regime, financial and human resources for the implementation of water, ecosystems and environmental management plans are often not adequate.

Fair Governance

The governance system established by the Special Law has sometimes been contested, especially on issues of legitimacy and transparency of decisions, and on the difficulty to access information and to discuss problems and solutions constructively. Actors tend to blame each other for this institutional stalemate. Respondents also acknowledge that thanks to the Special Law regime, which charged the State of overseeing major safeguarding works and a private concessionaire of executing the works, many measures could be quickly implemented and extensive scientific knowledge for the management of the lagoon generated.

Figure 3.3 Adaptive Capacity Wheel applied to the Venice lagoon case



Effect of institution on adaptive capacity	Score	Aggregated scores for dimensions and adaptive capacity as a whole
Positive effect	2	1,01 to 2,00
Slightly positive effect	1	0,01 to 1,00
Neutral or no effect	0	0
Slightly negative effect	-1	-0,01 to -1,00
Negative effect	-2	-1,01 to -2,00

Table 3.1 Adaptive Capacity Wheel explanation for the Venice lagoon

Dimension	Criteria: score and explanation
Variety	*Problem frames and solutions (-1)*: many problem frames on several issues (e.g. protection from flooding, pollution abatement, and nature management); solutions more oriented to infrastructure *Multi actor, level and sector (+1)*: a number of public, public-private and private actors are involved in water, ecosystems and environmental management; lack of coordination of instruments and actions at different vertical and horizontal level is source of inefficiency (e.g. environmental monitoring, spatial and sectoral planning) *Diversity (-1):* diversity depends on the sector (more on hydraulic security and ecosystems management) and it is limited to infrastructure *Redundancy (+1):* some overlap of competences and actions (e.g. tidal forecasts, environmental monitoring; water management) but no coordination
Learning capacity	*Trust (-2):* local actors do not trust each other actions and scientific knowledge; two major reasons for this: 1) the long lasting dispute about solutions to safeguarding Venice; 2) the competition among governmental actors to obtain national resources for implementing safeguarding measures *Single loop learning (+2):* great investments on improving environmental knowledge of the lagoon have been done since early 1980s. Knowledge has been used for experimenting and improving environmental management practises (e.g. morphological reconstruction) *Double loop learning (-2):* limited room for questioning values due to lack of trust and not complete free flow of knowledge; court cases do not generate learning because the parties go to court with the intention to suspend policy effects or infrastructural works *Discuss doubts (-2):* a number of discussions about scientific or technical doubts degenerated in conflicts brought to court (e.g. mobile barriers) *Institutional memory (0):* a lot of knowledge and information has been generated about Venice; not all knowledge is shared within the system as many organizations depend on governments or governments' funds and governments do not always make knowledge public available
Room for autonomous change	*Continuous access to information (+1):* there is regular communication to the public about expected floods through a daily tidal forecast bulletin; information on climate change scenarios and impacts is limited because of not sufficient studies yet; not all scientific knowledge is shared in the system *Act according to plan (+1):* most of the safeguarding measures foreseen in the Special Law have been implemented (mobile barriers, monitoring, morphological restoration, coastal defences); some measures are behind schedule (e.g. water pollution abatement in the catchment basin) *Ability to improvise (+2):* Venetians are well adapted to frequent flooding: e.g. they place barriers on the front door, use pumps, make valuable belongings easy to remove, wear boots; local authority have adjusted regulations and provide services that allow citizens to adjust behaviour in case of flooding (e.g. tidal forecast service)
Leadership	*Visionary (-1):* the debate about the future of Venice has polarized the political, scientific and social community for decades and still at present local actors have different ideas; respondents did not provide a clear vision for Venice in 50 years time, focussing on everyday or near future issues *Entrepreneurial (+1):* the CVN succeeded to implement the safeguarding measures and to build the storm surge barriers and to promote the barriers and their technology at international level; similar successful private initiatives in the systems are missing *Collaborative (-2):* local actors call for a new Special Law defining a novel governance of the lagoon, the catchment basin and the near-shore sea but the discussion is not going further that a draft law; governmental actors cannot agree on the leadership of a single steering authority for the management of the watershed; most respondents agree that cooperation is limited to a few sectors and activities and that it is not sufficient to effectively manage the lagoon; no collaborative efforts to study climate change and develop adaptation plan and measures for the whole watershed
Resources	*Authority (+1):* by using their formal authority governments succeed to make decisions even in situations of conflicting positions that cannot be solved; a tendency to make quick decisions and not engage in full discussion and to claim leading roles in the management of the lagoon suggest excessive use of formal authority *Human (-1):* education and studies specifically on climate change have only recently started *Financial (-1):* one third of the large investment for the safeguarding of Venice in the past 30 year was for infrastructure that will protect from sea-level rise (i.e. storm surge barriers, local defences, coastal defences); only resources to finish the storm surge barriers are ensured for the future; need to find local resources to complete other works and to do the maintenance; not sufficient financial resources for implementing EU regulations; some investments on climate change scenarios and impacts only recently started

Dimension	Criteria: score and explanation
Fair governance	*Legitimacy (-1):* transparency of decision–making processes and availability of knowledge have improved over time but are still not sufficient; decisions are not always legitimated because of lack of trust among local actors *Equity (0):* respondents consider the Special Law to have brought positive as well as negative outcomes; accounts for the positive the fact that many safeguarding infrastructure would not have been done without a private concessionaire of the State to carry out the works; on the negatives, the fact that this regime eroded trust and cooperation among actors *Responsiveness (-1):* difficulty to establish open dialogue among authorities themselves, and authorities, the public and the scientific community *Accountability (-2):* actors tend to blame each other for unsolved problems, difficult cooperation, limited share of knowledge and information

3.4 Case study 2: Wadden Sea

One of the most important ecosystems in the Netherlands is the Wadden Sea. The Wadden Sea is an intertidal system of islands, sandbanks, mud flats, tidal creeks, and deeper gullies stretching from the north of the Netherlands along the German coast to Denmark. Figure 3.4 on the left side, shows the Dutch Wadden Sea with its five inhabited islands, and on the mainland the seaports of Den Helder, Harlingen, and Delfzijl; on the right side the satellite picture shows the gullies, sandbanks, and mudflats, the dunes on the islands, and the agricultural use on the mainland. The islands once started off as sandbanks, and when they were high enough they became populated, first with plants and animals and later with humans (since about 1300 AD). They are still moving slowly in a northeast direction at a speed of a few centimeters per year.

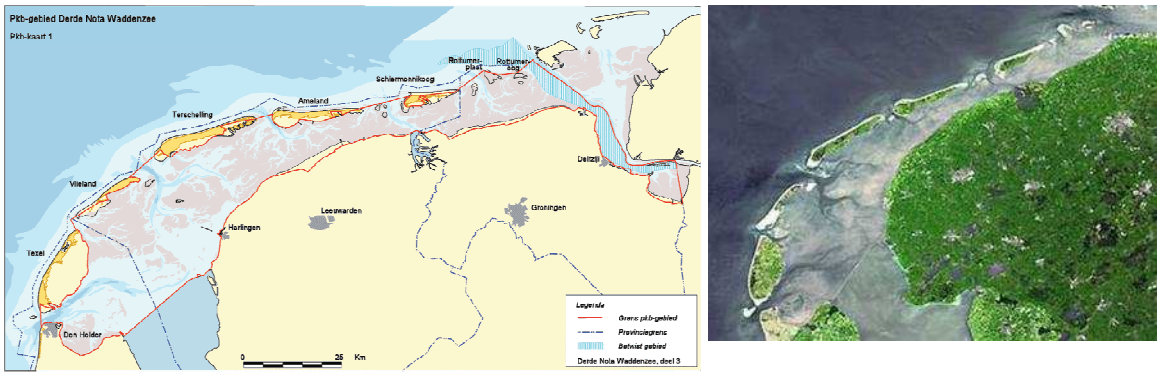
The Wadden Sea functions as an important habitat for fish, shellfish, and migrating birds (Herman et al. 2009). At the top of its food web is a population of seals that is doing rather well. Due to over-fishing, there are no economically profitable amounts of fish left in the Dutch Wadden Sea; but mechanical mussel and shrimp fishing is still continued, as well as cockle fishing by hand. The ecosystem is under pressure from shipping, pollution, and other human influences. At the same time, the beauty of the area attracts many tourists.

By Dutch standards, the Wadden Sea area is lightly populated, with about a quarter of a million inhabitants in eighteen municipalities. The five islands are inhabited by about 23,000 people in total. In the summer, this number increases tenfold because of the many tourists on the islands.

The main economic activities in the Wadden are mining of natural gas, shellfish and shrimp fisheries, tourism and recreation, farming (potatoes, cattle, and sheep), and harbors with connected industries. There is an important marine harbor in Den Helder

and there is also a military training area. There are many small marinas in the islands and along the coast of the mainland; furthermore, there are two large industrial harbors at the mouth of the river Ems (Groningen Seaport and Delfzijl). In these harbors, traditional energy production as well as bio-energy is important. A fourth relatively large harbor at Harlingen is mainly for pleasure vessels and a ferry service to the islands.

Figure 3.4 The Dutch part of the Wadden Sea



Source: (VROM 2007, left side)*; satellite image from Google Earth (right side)*

3.4.1 Expected impacts of climate change

The impacts of climate change on the Wadden region fall into two categories: first, sea-level rise combined with land subsidence; second, increased temperature of sea water. If the sea level rises quicker than the sedimentation process, the Wadden Sea may change into a shallow sea instead of having the mud flats and sandbanks for foraging and resting. It would then lose its function for many species. The rise in water temperature seems to disturb the relations in the food web; for example, shrimp seem to enter the Wadden Sea earlier in spring, thereby eating more of the fish eggs and mussel seeds than before. Also, exotic species may thrive at higher temperatures.

Another important impact is the threat to the safety of the human populations of the Wadden islands. These islands have an elevation of only a few meters above the present sea level, and a part of the islands is already a little bit below sea level (protected by dikes). If the sea level would rise substantially, it would not be possible to protect the islands to flooding with dikes, because a dangerously deep 'bathtub' would be made in the middle of the sea. If the natural process of sand transport and sedimentation would be allowed to continue, the islands would stay above sea level on their own. The downside of this natural solution is that the islands will move eastwards and the people

living on it will have to give up their built environment in the west every century or so (Kabat et al. 2009). However, if society insists on protecting the present human settlements with dikes and fixing the islands in place, permanent inhabitation may become impossible.

3.4.2 Governance arrangements

The Wadden Sea is shared by three nations: the Netherlands, Germany, and Denmark. Thirty-one governmental bodies are involved in policy and management of the Dutch Wadden Sea: five state departments (the Ministry of Transport, Public Works, and Water Management; the Ministry of Spatial Planning, Housing, and the Environment; the Ministry of Agriculture, Nature, and Food Security; the Ministry of Economic Affairs; and the Ministry of Defense), three provincial governments, four water boards, and eighteen municipalities. To coordinate all governmental efforts, a special body has been established since 2004: the Regional Committee for the Wadden Area (*Regionaal College Waddengebied*).

In addition, there is a large number of other stakeholders, of which some (fisheries, farming, and tourism) are more closely linked to local biodiversity issues than others (harbors, shipping, chemical industries, energy production, and mining for oil and gas). The fact that the Wadden's nature is highly valued has given rise to a long list of NGOs whose objective is to defend it. Eight of these groups are united under the umbrella group *Wadden Natuurlijk* (Wadden Naturally).

There is general agreement across government agencies, NGOs, and the private sector that the main goal for the Wadden area is "sustainable protection and development of the Wadden Sea as a nature area and the preservation of the unique open landscape" (Meijer et al. 2004; VROM 2007). However, in the past, the parties have disagreed substantially on how to achieve this goal. Before 2004, the conflict and distrust had grown to such a level that a State Committee was installed to advice on how to proceed. The Meijer Committee published its report in 2004. Based on this report, the issues were in large part solved: gas drilling was allowed under strict conditions; mechanical cockle fishing was prohibited; an organization for the development and coordination of scientific knowledge about the Wadden was established (the Wadden Academy), and a Wadden Fund of 800 million Euros was created (based on the gas revenues) with which local development and knowledge could be supported for a period of twenty years.

There is a lot of dialogue between stakeholders; and the number of networks and coalitions (including those supported by the Wadden Fund) is growing.

In 2008 another conflict arose with the mussel fisheries (Klostermann et al. 2009). The sector was successfully sued in court, and fishing of mussel seed in the Wadden was prohibited. The verdict of the Council of State forced parties to look for new solutions. A Mussels Covenant was signed by the mussels sector, the Ministry of Agriculture, Nature, and Food Security, and the environmental NGOs. The covenant stated that parties would look for new, innovative ways of mussel fishing and breeding that are not harmful to the Wadden ecosystem (Heldoorn 2008; LNV 2008).

3.4.3 Results of applying the ACW to the Wadden Sea case

The application of the ACW to the case study is presented in Figure 3.5. Table 3.2 summarizes the key findings of the analysis.

Variety

The Wadden Sea institutions embed a great deal of variety with respect to different kinds of businesses, policy visions, organizations and governmental and non-governmental actors in the governance process. Moreover, the Wadden Sea region offers room for innovative governance experiments like the Wadden Sea Covenant and the Wadden Sea Fund. Some respondents variety do not experience the as positive; they think large differences in opinion hinder effective governance progress. Also, there is not much variety with respect to different practical options for adaptation in the region: as of now the focus is on sand supplementations. Thus, there is variation in opinions, not in solutions.

Learning Capacity

The Wadden Sea institutions score high on the dimension of learning. They provide for learning in several ways: knowledge development and development of new technologies; monitoring; providing budgets for sustainable development and climate change adaptation; and education and awareness raising of civilians, youth, tourists, leisure and nature organizations. The Wadden Academy collects and collates knowledge products on the Wadden Sea. Overall, the institutions for the Wadden Sea embed a high learning capacity. Problems and structures are complex and the learning process is difficult; however, not much more can be done to increase learning.

Room for Autonomous Change

The institutional room for autonomous change is limited with respect to the Wadden Sea because many rules originate from national and European policies. However, regional and local organizations (water authorities, emergency organizations, water leisure associations, ferry services and governmental bodies) have all implemented their own measures to cope with rising waters. Moreover, some respondents think that the fragmented policy interference in the area together with little authority and control do create room for autonomous actions.

Leadership

The main conclusion on this dimension is that there is no central form of steering for the Wadden Sea region. There are 31 different governmental bodies involved in the governing of the Wadden Sea region; the Regional Directorate Wadden Sea was installed to manage this diverse government process in a united process; however, this body has little formal authority compared with the 31 governments it is working for. Respondents value the lack of leadership qualities in the Wadden Sea region differently. Most perceive the lack as a problem, causing chaos and a lack of authority. This is especially a problem under changing climatic conditions where leadership may serve to guide a transition. Others see the benefits of a lack of leadership. They argue that individuals are provided with more room to enter into innovative coalitions.

Resources

There is no structural financial resource for obligations following from national and European policies, like the development of a management plan that is obligatory in the Nature Protection Act and Natura 2000. The most important financial resource at this point is the Wadden Fund, which is used only on a very limited basis for adaptation. Human resources are also limited; few people have been appointed for nature management or for enforcement of regulations, so control is weak and fragmented. As explained before, there is a lack of authority.

Fair Governance

Overall, Dutch institutions are considered to be fair and there is room for open and honest discussions. A perceived shortcoming in the Wadden Sea region is an overrepresentation of economic concerns over nature concerns.

Figure 3.5 Adaptive Capacity Wheel applied to the Wadden Sea case

Effect of institution on adaptive capacity	Score	Aggregated scores for dimensions and adaptive capacity as a whole
Positive effect	2	1,01 to 2,00
Slightly positive effect	1	0,01 to 1,00
Neutral or no effect	0	0
Slightly negative effect	-1	-0,01 to -1,00
Negative effect	-2	-1,01 to -2,00

Table 3.2 Adaptive Capacity Wheel explanation for the Wadden Sea

Dimension	Criteria: score and explanation
Variety	*Problem frames and solutions (-1)*: many problem definitions, few ideas on solutions; focus is on sand supplementations *Multi actor, level and sector (+2)*: great deal of variety with respect to different kinds of businesses, governmental and non-governmental actors in the governance process *Diversity (0): u*nclear, on one hand sand supplying as only solution for management of the sea coast, on the other, area specific planning processes offer tailor made solutions locally on the land surface, innovative governance experiments like the Wadden Sea Covenant and the Wadden Fund *Redundancy (-2): b*attle between economy and nature, while quality of nature is being reduced
Learning capacity	*Trust (+1): s*lowly increasing through cooperative efforts; conflicts increasingly managed through social dialogue *Single loop learning (+2):* education on nature friendly behaviour organized by water sports associations *Double loop learning (+1):* introduction of new legislation; court cases generate learning, Wadden Academy starts to ask questions to understand the entire Wadden system and collects and collates knowledge products on the Wadden Sea *Discuss doubts (+2): o*pen communication on everyone's doubts *Institutional memory (+2):* an extremely large amount of reports has been published on the Wadden Sea
Room for autonomous change	*Continuous access to information (-2): f*armers living close to the Wadden Sea and islanders are familiar with occasional extreme weather patterns in the region; on the mainland the majority does not know *Act according to plan (+1):* regional process well organised, safe dikes, regional and local organizations (water authorities, emergency organizations, water leisure associations, ferry services and governmental bodies) have all implemented their own measures to cope with rising waters but little support for innovative, long term solutions *Ability to improvise (-1):* self-supportive culture, fragmented policy interference in the area together with little authority and control create room for autonomous actions but hardly applied to climate change issues; the nation-wide trend to fully trust the national government to provide protection measures against such patterns is also visible in the Wadden Sea region
Leadership	*Visionary (-2):* No visionary leadership which is especially a problem under changing climatic conditions where leadership may serve to guide a transition *Entrepreneurial (-1):* Many entrepreneurs, but no coordination so no leadership *Collaborative (+1):* no central form of steering for the Wadden Sea region but there has to be some collaborative leadership considering the many new alliances

Dimension	Criteria: score and explanation
Resources	*Authority (-2):* authority is not used openly; the Regional Directorate Wadden Sea has little formal authority compared with the 31 governments it is working for *Human (-1):* for a large part of the Wadden Sea no people have been appointed for management and too little enforcement of the rules *Financial (0):* the most important financial resource is the Wadden Fund, which is used only on a very limited basis for adaptation; the Delta Fund and the WILG are other budgets potentially available for adaptation in the Wadden Sea region
Fair governance	*Legitimacy (0):* court cases against governmental decisions are won, which shows that rules are not clear or not properly applied; the court decisions are respected and followed up by looking for new solutions cooperatively *Equity (-1):* corruption and violence are limited and there is room for open and honest discussions; still, decisions often not fair for nature and sometimes not fair for the economic actors *Responsiveness (+2):* open debate, collaborative search for new, responsive institutions like the Mussels covenant and the covenant on behavioural rules for recreational ships *Accountability (-2):* no cumulative judgement of permits, too little enforcement

3.5 Comparison of the case studies

In this paragraph we compare the two case studies. First we look at the two physical systems. Then the institutional arrangements are compared, and finally a comparison is carried out of the estimated adaptive capacity in each case study.

3.5.1 Similarities and differences between the physical systems of Venice and Wadden

We found many similarities Table 3.3. Both areas are intertidal systems with similar biodiversity; they are undergoing similar economic uses by humans; there is a presence of natural gas in both areas; and there is the same population dynamic of reduced inhabitants and increased tourism. As may be expected, the similar economic uses and population dynamics lead to the same types of pressure, such as erosion and loss of biodiversity. The main impact of climate change on these coastal areas is also the same: areas that are now temporarily dry might become permanently submerged, and areas that are now mostly dry (and where people are living) may suffer from more frequent flooding.

There also are some important differences between the two areas Table 3.4. Firstly, Venice is a historical city while the Wadden area has a rural character. Secondly, in the city of Venice floods occur several times each year, but in the urbanized areas of the Wadden they rarely occur. Thirdly, gas is exploited in the Wadden Sea but in the Adriatic Sea it is not. Other differences include the number of tourists (an order of magnitude larger in Venice compared to Wadden) and the magnitude of the environmental pressures (also larger in the Venice Lagoon). We conclude that the

physical systems are quite comparable, especially when we look at the environmental pressures.

Table 3.3 Similarities between the physical system of Venice and Wadden

	Similarities
Natural system	Intertidal system with mud flats, shallows and salt marshes
	Estuarine ecosystem, rich in biodiversity
	Function as nursery and feeding area for migrating birds and fishes
	Presence of natural gas under the sea
Socio-economic system	Number of inhabitants decreases
	Number of tourists increases
	Fishing sector decreases
	Waters are heavily human managed (rivers, dams, dikes, barriers)
Pressures	Shipping and dredging causes erosion and suspension of polluted sediments
	Shellfish fishing activities cause reduction of sea grass and erosion
	Fishing in general causes loss of biodiversity
	Climate change may lead to permanent submersion, disappearance of salt marshes and change of biodiversity due to rise in water temperature

Table 3.4 Differences in the physical system of Venice and Wadden

	Venice	**Wadden**
Natural system	Venice lagoon is more enclosed by land, at the inner edges more influenced by the watershed than by the Adriatic Sea, brackish and at the inlets more influenced by the sea, salty	Wadden sea is protected by islands but more open to influence from the North Sea, salty
	Watershed influences water quality	North sea influences sediment balance
	City of Venice is flooded 10-12 times per year because of high tidal level	On the Wadden coast and islands floods are rare and occur only because of extreme rainfall
Socio-economic system	Gas exploitation is prohibited	Gas is exploited and effects on soil subsidence are monitored
	Venice is an historical city	Wadden is rural area
	In Venice, 25 million tourists per year for old city (seen as a problem)	In Wadden 2 million tourists spread over the 5 islands (seen as a solution)
	Venice lagoon is contained in one country (Italy)	Wadden sea stretches along three countries (Netherlands, Germany and Denmark)
	Safety created with barriers	Safety created with sand supply and dikes
	From free fishing to fish farms in the lagoon, few restrictions	Cockle fishery (shell fish) forbidden; fishermen are compensated through the Wadden Fund; mussel seed is fished and bred in fish farms elsewhere in the Netherlands
Pressures	Venice: more pressures on environment, sustainability of total system is the issue	Wadden: less pressures, nature most important function but under threat
	Agricultural, industrial and civil pollution from watershed and lagoon	Water pollution under control, apart from effects of dredging
	Last disaster: 1966 flood causing economic and historic damage	Last disaster: in 1953 6 people drowned on Texel
	Climate change expected to increase frequency of flooding	Climate change threatens safety on islands in more distant future

3.5.2 Similarities and differences between the institutions in Venice and Wadden

We now take a look at the institutions by which these areas are governed. Partly they are the same (see Table 3.5) because several international institutions are effective both in the Wadden and the Venice area, i.e. European regulations and their recognition as UNESCO world heritage sites. There are also other similarities such as associations in which trades unite (fishermen, tourism) and advisory committees that are installed in an effort to resolve conflicts of interest. Both regions also prefer to work on their problems in their own way instead of following national policies, and both regions lack resources to maintain what is valuable, as well as resources to enforce the rules.

Table 3.6 shows the list of differences in the institutions. Under the dimension "Variety" we see that, whereas in the Venice lagoon dialogue is seen as a source of conflict, in the Wadden area dialogue with many actors is seen as a solution. The fact that there is more dialogue in the Wadden probably has led to a larger variety of solutions under discussion, something that we consider as beneficial to adaptive capacity. The impact of climate change is uncertain, therefore, we do not know what problems to expect, and a larger variety of solutions can potentially solve different kinds of problems.

Under the dimension "Learning", a lack of trust among actors is revealed in Venice as well as a lack of confidence in scientific knowledge generated by the local public and private organizations. In Venice much scientific knowledge is developed for the purpose of building safeguarding infrastructure and it is not always shared with local stakeholders and the public. This limits dialogue and cooperation. In the Wadden area, trust seems to be growing. Decision-making is based on open dialogue and the growing knowledge is available to everyone through the Wadden Academy. These factors lead to a better score on learning for the Wadden, compared to Venice. The care for cultural heritage, however, seems to be better in Venice than in the Wadden area.

Another important difference lies in the dimension "Room for autonomous change". People in Venice are used to regular flooding, and although it is seen as a nuisance, they are adapted to it. A series of technical and organizational measures have been adopted to reduce the damages: widely available information on tidal levels, storage of vulnerable assets, electricity meters and connexion boxes above the level of floods, vacating of some low-lying ground floors, and providing temporary higher walkways along the main pedestrian routes. In contrast, in the Wadden area people count on the

government to prevent floods. Therefore Venice has a better score on "room for autonomous change".

Under the dimension "Leadership", we encounter the fact that in Venice cooperation among governments is limited to a few sectors and activities. The governance system has often been contested, especially on issues of legitimacy and transparency of the decisions and on the difficulty to access information and to discuss problems and solutions constructively. In the Wadden area there is a big effort to cooperate. This is not easy because decision-making processes are slow and many respondents complain about a lack of visionary leadership, especially with respect to climate change.

For the dimension "Resources", we notice that in the Wadden, governments do not openly claim the right to decide on the basis of their level of authority, even though the state level obviously is powerful due to the income from the Wadden gas. Governments treat each other in a friendly way because they want to cooperate. In Venice, the governmental authorities act in an opposite way: every governmental body claims to have the right to make decisions on what has to happen in Venice often disregarding other parties' opinions. They basically are busy claiming their individual power (formal authority). However, the local authorities seem to have little power. One reason is that they cannot monopolize the income from tourism. This makes economic actors in Venice less dependent on their governments. Every Venetian citizen, in fact, can offer transport, lodging, and merchandise without paying for the externalities of these activities. The lack of trust in local authorities is probably the reason why Venetian citizens do not want to pay the costs of externalities of tourism (they do not trust that local governments would make good use of the money). Local governments are also afraid of creating mechanisms to make tourists and the tourism sector pay for the environmental externalities for two reasons. First, they are afraid of damaging the tourism sector; second, they are afraid of losing votes. So we see that trust and resources are related. Venetian local governments do not try to gain power by building alliances, due to a lack of trust.

Finally, we look at the dimension "Fair governance". Venice has had its own special national regulation for three decades. International and European regulations are implemented, but it is difficult to integrate the requirements of the European regulations into the existing governance system because the new regulation is perceived not to match the specific needs of the lagoon. In the Wadden, European and international rules

are implemented and considered beneficial. The Dutch Ministry of Transport, Public Works, and Water Management, for example, paid for the organization of a broad dialogue on the Water Framework Directive[16] in the Wadden area.

Table 3.5 Similarities in institutions between Wadden and Venice

Variety	Presence of recreational and tourist associations, from private sector as well as citizens (sailing, pleasure boats, etc.) Industrial associations Fishing associations Local media: newspapers, radio, internet No mechanism to negotiate different opinions to an end conclusion
Learning capacity	Not sufficient knowledge on climate change impacts
Room for autonomous change	Regional chauvinism ("give us the money and we will solve it regionally") Nature protection laws seen as too strict for economic development
Leadership	Difference in views if the Wadden / Venice lagoon is one entity or not Advisory committees (Commission Meyer in Wadden, Ufficio di Piano in Venice) Organizations that unite involved governments (*Regionaal College Waddengebied,* Inter-ministerial committee for Venice) Lack of vision for the future
Resources	Lack of financial resources in general, and especially for nature management and cultural heritage (in Venice it is more the allocation on irregular basis that generates problems than the amount) Spatial plans of lower order have to comply with spatial plans of higher order Lack of personnel for enforcement of regulations; in both cases illegal harvesting of fish and shellfish is difficult to control
Fair governance	EU regulations: Natura 2000 protected areas, Water Framework Directive UNESCO management plan requested by 2012 Many court cases to resolve conflicts

Table 3.6 Differences in institutions between Wadden and Venice

Dimensions	**Venice**	**Wadden**
Variety	Venice 7 governments involved in 4 levels for safeguarding works and another 15 for ecosystems and environment management	Dutch Wadden 31 governments involved in 3 levels
	Some NGO's present for environmental protection; limited role in decision-making	Strong role of nature interest groups in decision-making
	Many organizations for historical and cultural heritage conservation	Cultural and architectural heritage undervalued and less represented
	No mechanism to include different opinions in debate; dialogue is seen as a source of conflict	Lot of investments in participative governance; dialogue is seen as a solution to resolve conflict
	Most resources went into infrastructure and less in economic incentives and regulations	Different solutions explored and implemented (dikes, sand supply, building with nature, energy production, etc.)

[16] Directive 2000/60/EC of the European Parliament and of the Council Establishing a Framework for the Community Action in the Field of Water Policy of 23 October 2000.

Dimensions	Venice	Wadden
Learning capacity	Scientific knowledge is not always shared in the system	The Wadden Academy makes scientific knowledge available
	Lack of trust in other parties	Level of trust is improving since 2004
	Presence of two universities in the lagoon itself and several research institutes	Some ecological research institutes present in the Wadden
Room for autonomous change	Venice population is used to flooding	Dutch people have forgotten how to react on flooding
	The Italian culture is more to react when disaster happens	The Dutch culture is more to prevent disaster
	In Venice regular information to the public on flooding	In Wadden less info on high tides to the public
Leadership	In Venice a concessionaire of the State builds the storm surge barriers under the supervision of the government	In Wadden water management works are carried out through public calls of the government
	In Venice cooperation among governments is limited to some activities, for the rest each agency implements its own measures	In Wadden governments cooperate in a uniting body the *Regionaal College Waddengebied*
	In Venice, the local agency of the Ministry of Infrastructure and its concessionaire are influential actors	In Wadden, no one has the most power; public authorities make the decision-making process transparent
Resources	In Venice governments claim authority excessively	In Wadden governments do not claim authority
	Tourism is the main economic resource available to everyone in Venice	Natural gas is an important economic resource monopolized by the Dutch state and partly fed back to Wadden through Wadden Fund
Fair governance	Preference to create new formal institutions (Special Law for Venice)	Preference to use existing laws and even to merge existing laws into integrated laws
	World heritage since 1987, has UNESCO office	World heritage since 2009
	Venice lagoon is not a Ramsar site	Wadden sea (up to Denmark) contains 8 Ramsar sites covering 1 million hectares
	EU Water Framework Directive: there is a management plan but no authority appointed to implement it (in the interim the existing water boards implement the plan)	EU Water Framework Directive: implementation addressed by state level in cooperation with regional governments and stakeholders and well underway

3.6 Conclusions and recommendations

3.6.1 Conclusions about adaptive capacity in the Venice lagoon

There is evidence of some adaptive capacity to climate change in the Venice region: several governmental organizations deal with water, ecosystems and environmental management in the Venice lagoon; several regulations and services allow autonomous adaptation to flooding; resources have recently begun to be invested in scientific knowledge on climate change; experimentation allows the improvement of technology and environmental management practices; hydraulic defence infrastructure is under construction and in general considered to be adequate to protect Venice from sea-level

rise (which is viewed as the main problem in the long term) for the next one hundred years. However, we estimate the overall adaptive capacity of the institutional system for water, ecosystems and environment in the Venice lagoon as insufficient. The following main problems were identified.

- A lack of trust among local stakeholders is a source of insufficient cooperation, lack of confidence in scientific knowledge, and difficulty in sharing it. There is little room for open and constructive discussion of new ideas, and it is difficult to challenge the way strategies are defined. Establishing an open dialogue about the future of Venice under conditions of climate change is challenging because there is no shared vision of the future of Venice, and adaptation goals have not been made clear.

- The governance system is fragmented at different governmental and spatial scales. A climate adaptation strategy for the whole watershed is not under discussion, and climate studies are carried out by different organizations separately. Local governmental authorities call for a single water and environmental management authority to govern the lagoon, the catchment basin and the near-shore sea. In an attempt to streamline, each governmental body claims to be in the best position to acquire this role.

- The absence of a regular flow of resources to complete the safeguarding works, and of mechanisms to generate local resources for the maintenance of the infrastructure, is a key issue. Plans and programs not included in the Special Law often lack resources to be fully implemented.

3.6.2 Conclusions about adaptive capacity in the Wadden Sea

The analysis has shown that the capacity to learn is a main strength of the institutional system in the Wadden area. Other positive developments are the open dialogue in which many stakeholders are actively involved, and the increasing number of cooperative alliances forming in the Wadden area. New institutions like the Wadden Fund and the Wadden Academy play a role in these positive aspects. However, we estimate the overall adaptive capacity of the institutional system for water, ecosystems and environment in the Wadden area as insufficient. The following main problems with increasing the adaptive capacity in the Wadden Sea region were identified:

- The main debate in the region is not how robust present policies are in a timeframe of one hundred years, but rather how policymakers can cope with recent developments in the coming five years. Adaptation goals have not been made clear, and a shared vision on the future goals under conditions of climate change is lacking.
- Governance in the Wadden Sea region is fragmented and complex. While most stakeholders agree that laws should allow for more natural dynamics, and that governmental decisions should favour nature over economic concerns, no one seems prepared to take action, and everyone shifts responsibilities to other actors or levels.
- A structural lack of human resources, especially for enforcement of regulations and for nature management, may be an important barrier for improvement.

3.6.3 Conclusion on comparison of cases

Summarizing the results of the comparison, we conclude that the Venice and Wadden regions are strikingly similar in their natural aspects as well as in the patters of economic use, and, consequently, also in the environmental pressures. Although some institutions are also similar, we see a quite different pattern in the governance of the two environmental systems.

In Venice, a Special Law has empowered a local agency of the Ministry of Infrastructure and its concessionaire to generate scientific knowledge and carry out major safeguarding works. Local governments are less influential. The long-lasting dispute about solutions to safeguarding Venice and the politicization of scientific knowledge have eroded trust among governmental authorities and between governmental authorities and citizens. This has led to insufficient cooperation among public actors and disputes to be often brought to court by environmental groups. Climate change has only recently entered the political agenda (except for the flood protection infrastructure) and may serve as a unifying external threat.

In the Wadden, the national government can use revenues from Wadden gas exploitation to support the decision-making process with new knowledge and experiments. There is a consensus process going on to resolve the conflict between nature conservation and economic use of the Wadden Sea. Climate change is slowly

gaining attention in this process. It is not clear, however, if consensus will appear on time (i.e. before a climate-related disaster happens).

While the physical circumstances are similar and the institutional setting is different, strikingly, the outcome of the analysis is again similar: neither of these two institutional systems has enough adaptive capacity to respond to climate change. Resources are a limiting factor for both regions. In Venice, lack of cooperation and accountability limit learning while we have recorded relatively good scores in the areas of "Variety" and "Room for autonomous change". In the Wadden case, the score on "Learning" is good, but all other dimensions are rather weak, and the "Resources" dimension seems the worst. This is mainly due to a lack of human resources. In the Wadden a lack of authority and leadership limits the decision-making process.

3.6.4 Reflection on the adaptive capacity wheel methodology

The ACW methodology was found by the authors to be useful. The set of 22 criteria proved to be a valuable tool, because it helped to create a balanced overview of relevant aspects, and it made it possible to compare the case studies in a structured way. The set of 22 criteria requires a lot of time, but the effort is rewarded with a rather complete understanding of the institutional system. It shows how the same institutional element can lead to a positive score on one criterion while it is less positive from another viewpoint (for example, a lack of authority may enhance learning and variety). The completed circle shows how strengths and weaknesses are related and where one could start with improving the institutional system. Due to the simple colour scheme improvements can also be discussed in an interactive session.

However, the tool also had its difficulties. Firstly, interpretation of the criteria was not always straightforward. It would be helpful if the method were more explicit on how to interpret the different criteria, especially when it is done from different cultural backgrounds. Secondly, the scoring process was difficult. Although there is no real solution to the subjectivity of the scores, they can be made more robust by scoring in several rounds: first by the main researcher, then by colleagues who are knowledgeable about the studied area, and finally there could be a workshop with the respondents to discuss the scores. This would lead to adjustments and a better argumentation for each score. A dialogue with the respondents also serves the main purpose of the ACW, namely to detect possible weaknesses in the institutions and to discuss them with the involved governments and other stakeholders.

3.6.5 Implication of this research for the future of the Venice lagoon and the Wadden Sea: recommendations

Although neither the Venice nor the Wadden Sea governance systems can be presented as successful cases with respect to adaptive capacity of institutions, the two regions can learn something from each other.

The following three recommendations address the most critical weaknesses of the ACW for the Venice case, i.e. trust, learning, cooperation, leadership, and resources.

- Intuitively, the lack of trust in the Venice area seems a crucial factor. Looking for more cooperation among governmental agencies themselves, but also with external stakeholders, such as private enterprises and citizens, thereby generating more trust, seems the first step that needs to be taken.
- An independent Venice Science Academy could be established to connect existing knowledge institutes and to stimulate others to do research. It could also periodically assess and evaluate research and monitoring activities, ensure sharing of the knowledge among all research institutes, and communicate knowledge to the public.
- A specific Venice Fund for financing research and maintenance of safeguarding works could be established. Money for the Venice Fund could come from tourism revenues and commercial and industrial port revenues, as well as some national funding.

For the Wadden area, a number of criteria were given low scores, and our recommendations are mainly oriented on improving those areas.

- We think the following conditions should be met for visionary leadership: create a long term agenda; communicate ideas from the local to the international level; innovate; and take some risk.
- The Wadden area can develop ways to inform the general public regularly on extreme weather events and the threat of flooding. In Venice, several parallel systems are developed, such as mobile-phone messages alerts, newspaper advertisements, sirens, and maps with safe exit routes.
- Concerning the lack of enforcement, more serious investment in human resources should be made. Also, the general public may be recruited to support

enforcement agencies, based on modern technologies, such as internet and mobile phones.

Recommendations applying to both regions are the following.

- Venice and Wadden should take climate change and long-term planning into greater account and use it to create a greater sense of shared responsibility about the future.
- Being on the World Heritage List is an acknowledgment that these sites are of outstanding value to humanity. They belong to all peoples of the world (UNESCO 2010). Both regions may call for greater international attention and support for dealing with the additional threats deriving from climate change which endanger the conservation of the two World Heritage sites.

We would like to conclude with a general observation. In the two studied regions, institutions for water, ecosystems and environmental management limit adaptive capacity of society to climate change. This is a common finding in climate studies that reflects the difficulty of dealing with uncertainty and risk that policymakers face these days. Reforming institutions, although it takes a long time, is crucial to more resistant social and ecological systems. Studying and comparing the institutions underlying policy processes, like it was done in this study, can help to identify new options for the design of formal institutions. For example, institutions can demand cooperation and learning in a more explicit way. However, the way people deal with formal institutions in practice is usually more important than the written text. These 'informal institutions' are often tacit and it can be hard to identify which ones inhibit the learning and decision making process. Still, we believe that in case of a stalemate or lack of progress, the sphere of informal institutions is the first place to be looking for improvements.

4 Adaptive co-management in the Venice lagoon? An analysis of current water and environmental management practices and prospects for change

Abstract

Adaptive co-management (ACM) is often suggested as a way of handling the modern challenges of environmental governance, which include uncertainty and complexity. ACM is a novel combination of the learning dimension of adaptive management and the linkage dimension of co-management. As suggested by Armitage et al. (2007), there is a great need for more insight on enabling policy environments and conditions of adaptive co-management success and failure. Picking up on this agenda our paper will provide a case study of the world famous Venice lagoon in Italy. We address the following questions: first, to which extent is adaptive co-management currently practiced in the Venice system? Second, to which extent is learning taking place in the Venice system? And third, how is learning related to the implementation or non-implementation of adaptive co-management in the Venice system?

Our analysis will be based on interviews with stakeholders and archive data. The paper shows that the prescriptions of adaptive co-management are hardly followed in the Venice lagoon, but some levels of cognitive learning do take place, be it very much within established management paradigms. Normative and relational learning (Huitema et al. 2010) is much rarer and when it occurs it seems to have a relatively opportunistic reason. We pose that especially the low levels of collaboration (the system was deliberately set up in a hierarchical and mono-centric way) and the limited possibilities for stakeholder participation are implicated in this finding as they cause low levels of social capital and incapacity to handle disagreements and uncertainty very well.

Key words: governance, co-management, institutions, learning, adaptiveness, Venice lagoon

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S. Munaretto conducted the planning and the analysis of the case study and wrote about it. D. Huitema supervised the analysis, contributed to design and write of the structural framework of the paper, the methodology and the discussion.

4.1 Introduction

These days it is hard to find anyone disagreeing with the notion that social-ecological systems (Berkes & Folke 1998) exhibit many 'wicked' traits such as non-reducibility, spontaneity and variability (Dryzek 1987). Those wanting to manage such systems face surprise, unpredictability, and the possibility of unexpected 'tipping points' (Lenton et al. 2008). The literatures on adaptive management (Gunderson & Holling 2002) and co-management (e.g. Wondolleck & Yaffee 2000) speak to these challenges, and these two literatures are currently seen as converging into a literature on adaptive co-management (Olsson et al. 2004; Armitage et al. 2007). Adaptive management emphasizes learning and uses structured experimentation in combination with flexibility as ways to achieve this. Co-management emphasizes the sharing of rights, responsibilities, and power between different levels and sectors of government and civil society. Adaptive co-management, then, is a novel combination of the learning dimension of adaptive management and the linkage dimension of co-management (Olsson et al. 2004; Armitage et al. 2007).

The literature on adaptive co-management contains four institutional prescriptions that should be followed to enhance adaptability. As these have been discussed in full by Huitema et al. (2009), here we only need to briefly summarize them. Our discussion will concentrate on the assumed benefits of following these prescriptions. We are aware that any of these prescriptions also implies certain difficulties (also discussed by Huitema et al. 2009), but find them less relevant for our present purposes.

The first prescription revolves around polycentricity. Polycentric governance systems are defined as systems in which "political authority is dispersed to separately constituted bodies with overlapping jurisdictions that do not stand in hierarchical relationship to each other" (Skelcher 2005 p. 89). The literature on polycentric governance initially focused on the importance of local self control, making governance fit with local political preferences (e.g. Ostrom et al. 1961). More recent literature (e.g. McGinnis 1999; Oakerson 1999; Dietz et al. 2003; Karkkainen 2004; Ostrom 2005) suggests that polycentric governance systems are more resilient and better able to cope with change and uncertainty. The reasons for this are, first, that issues with different geographical scopes can be managed at different scales. Secondly, polycentric systems have a high degree of overlap and redundancy, and this makes them less vulnerable: if one unit fails, others may take over their functions (see e.g. Granovetter 1981; Perrow

1999). Finally, the large number of units makes it possible to experiment with new approaches so that the units can have the opportunity to learn from each other (Ostrom 2005 pp. 181-182).

The second prescription relates to public participation. We define public participation as the taking part, by ordinary citizens or their collectives, in the processes of government and/or governance; we refer to situations in which a (substantial) number of citizens play a part in the process by which leaders are chosen and policies are shaped and implemented (Birch 2007). Typical advantages of public participation are almost all (directly or indirectly) associated with various forms of learning. Public participation is expected to contribute to a better understanding of the social-ecological system, as all relevant sources of information are used, to greater reflexivity; as actors learn to understand how others understand the issues, resulting in increased legitimacy and support for decisions taken; as actors are less likely to oppose decisions they have taken themselves, resulting in greater accountability and transparency; as decisions need to be publicly explained and motivated (see e.g. Renn et al. 1995; Coenen et al. 1998; Ridder et al. 2005; Mostert et al. 2008).

The third institutional prescription, experimentation, is about planned interventions in the social-ecological system and the monitoring of their results (e.g. Lee 1999; Richter et al. 2003). Full blown experiments are characterized by explicit hypotheses about relation between interventions and their effects, and by comparison with reference situations where no intervention was made. These are difficult to implement in real world governance settings, if only because treating two comparable situations differently results in opposition (Fischer 1995). This is why most experiments in reality are “quasi-experiments”, which refers to the fact that either a control group was not present or that no explicit hypothesis was formulated about the effects of the interventions beforehand. Interpreted this way, any intervention or policy can be seen as an experiment and a way of testing hypotheses (see e.g. Walters 1997; Pahl-Wostl 2006) and opportunity for learning. Indeed, learning is a key goal of experiments. In the policy sciences, experimentation is viewed as one of the most rigorous methodologies for factual learning, but the prospects for more reflexive forms of learning are often deemed to be somewhat dimmer (see for instance Fischer 1995; Greenberg et al. 2003). There is however a group of authors who suggest that experiments can function as “boundary objects” for bringing in multiple stakeholders. Even though the experiment might have only a factual learning agenda, greater reflexiveness might be an additional

effect as those involved in the experiment can improve network relations through repeated interactions and the emergence of trust (Lejano & Ingram 2009). This in turn is expected to increase their capacity to deal with uncertainty and change (e.g. Moberg & Galaz 2005).

The fourth prescription of adaptive co-management is to organize management at the bioregional level such as a river basin, also when such a bioregion crosses administrative boundaries. Among governance scholars, the creation of institutions at the appropriate scale is discussed as a matter of "optimization" (Ahn et al. 1998) or "fit" (Young 2002). Both concepts refer to the congruence or compatibility between ecosystems and institutional arrangements (Young 2002 pp. 20-22). The arguments speaking in favor of the creation of a bioregional approach are mainly related to the perceived failures of existing resource management institutions. These include lack of recognition of interdependencies at the river-basin scale; lack of cooperation between institutions; lack of transparency, making the institutional structure difficult to understand for "outsiders" and thereby limiting (public) participation; overlooking of problems that do not fit in established programs; and finally, the existence of a lax management setting in which special interests such as farmers and industry can dominate (Schlager & Blomquist 2000 pp. 2-3). River-basin-scale institutions are supposed to address these.

Lee (1999 p. 5) suggested a while ago that the idea "has been much more influential as an idea than as a way of doing conservation so far." Adaptive co-management is attractive as an idea but very hard to introduce and sustain in practice. Different responses to this conclusion, which still holds, are possible. One is to submit adaptive co-management as a Weberian "ideal type", declaring it only a hypothetical concept in the abstract and a subjective notion which might inspire practice but will never be fully realized. Another is more empirical; this would entail questions about what holds back the introduction of adaptive co-management in real life settings, but also an assessment of the consequences of non-implementation. This article is meant in the second vein. Thus we follow Armitage et al. (2007 pp. 6-10), who recently pointed to the need to move beyond "the limits" of adaptive co-management, and suggest "policy implications" as a key theme for research, pointing to the need for more insight on enabling policy environments and "conditions of adaptive co-management success and failure." Questions to be answered under these headings relate to ways to establish

cross-level linkages, the conditions for partnerships that really share power, and ways to move from instrumental learning to learning about appropriate goals.

One way to empirically learn more about enabling environments for adaptive co-management is to focus on case studies where the concept of adaptive co-management potentially has much added value but is not fully applied, or not fully applied yet. This article presents just such a case study, as we focus on the world famous Venice lagoon in Italy. The Venice lagoon presents a case study where the importance of water and environmental management is profound and uncertainties about future developments loom large.

The present article attempts to bring the discussion about the feasibility and efficacy of adaptive co-management further by answering three questions, centered on the management of the Venice lagoon in Italy:

- *To which extent is adaptive co-management currently practiced in the Venice system?*
- *To which extent is learning taking place in the Venice system?*
- *How is learning related to the implementation or non implementation of adaptive co-management?*

In the next section of this paper (section 4.2) we describe our methodological approach. In section 4.3 we introduce the social-ecological context of our case study. Then we apply the adaptive co-management prescriptions in the section 4.4 as a normative framework to assess ongoing water and environmental management efforts to safeguarding the Venice lagoon. In so doing, we provide a critique of the current safeguarding measures that are being implemented in this world famous city.

But just assessing the ongoing efforts in the Venice lagoon does not suffice. Furthering the analytical agenda related to ACM also requires understanding about the consequences of the implementation or non-implementation of the prescriptions in terms of the central goal of learning. To analyze the level of learning that is taking place in the management system of the Venice lagoon, we apply the typology of learning that was described in this journal by Huitema et al. (2010). This means we pay attention to cognitive, normative and relational learning that takes place in the management system. An elaboration of this typology can be found in section 4.5 and in section 4.6 we apply the typology to the Venice lagoon; in section 4.7 then we relate the levels of learning we

have found to the implementation of the prescriptions. We conclude this article by discussing our findings and providing suggestions for improving the management system so as to increase the possibilities for learning (section 4.8).

4.2 Data and methodological approach

In this article, we base ourselves on scientific literature, archive analysis, newspaper articles and interviews. Scientific literature includes articles on adaptive governance, learning and co-management and Venice management. Archive data used in this study (available on the Internet and on request to the organizations producing the data themselves) are the following:

- Legal documents: European regulation on water and nature management (i.e. Water Framework Directive and Birds and Habitat directives) and relative national and regional regulations to implement them; Italian laws and related regional and local regulations on the safeguarding of the Venice lagoon (i.e. the Special Law for Venice);
- Policy, plan and project documents derived from the Special Law and those derived from the EU, national and regional legislation listed above;
- Assessment and thematic reports of national, regional and local agencies and research centers, i.e. Veneto region, Ministry of Environment, Venice Municipality, Venice Province, Ufficio di Piano, Venice Water Authority; the material deals with: financing of the safeguarding works, state of the environment of the Venice lagoon (i.e. water, sediment and ecosystems quality); natural and socio-economic pressures and impacts on the lagoon environment (i.e. climate change, clam fishing, commercial and industrial port, tourism); socio-economic development issues (i.e. industrial and commercial port activity, tourism, redevelopment of the industrial area);
- National and local newspaper articles collected between 2004 and 2010 dealing with the safeguarding of Venice, water and environmental management.
- Reports, articles and documents published (either on the website or on paper) by a number of NGOs: Italia Nostra Venice Office, Assemblea Permanente NoMOSE, WWF, Ambiente Venezia, VAS–Verdi Ambiente Societá.

To broaden our sources of information, we interviewed high level policy-makers of national, regional and local governmental agencies, natural scientists working for local public and private research institutes and practitioners of local private and public organizations. They all are knowledgeable about the safeguarding of the Venice lagoon and in particular on water and environmental management. The interviewees were selected on the basis of their working position (we wanted to cover all level of government and the main sectoral agencies dealing with water and environment), their expertise, and their views on the safeguarding of Venice (for this we relied on the knowledge of the Venice system of the first author - see below for further explanation). Sixteen out of seventeen experts contacted were interviewed between March and June 2010. The interviewees requested to remain anonymous, and therefore a list of names is not provided and interviewees are only referred to by position. The person that did not accept to be interviewed told us to refer to the website as source of information and opinion of the group (it was an environmental NGO). Six interviews were conducted for this study and for a study on climate change impact and adaptation in Venice (see annex 2). During these interviews questions revolved around climate change and governance of the Venice lagoon, whereas all other interviews focused only on governance issues. Questions asked on governance regarded options and challenges for the safeguarding of Venice, the effectiveness and the impacts of the existing institutional arrangements, the visions for the future of Venice and the policy needs to reform the current institutional system.

To answer the first and second research questions, we have drawn on the interviews, the legal documents, the key organizations' policy, programs and plan documents, the NGOs documents and the newspaper articles. By analyzing this material we gained understanding about actors' perspectives, their networks and coalitions, authority and power relations, informal rules, and discourses on the safeguarding of Venice and their evolution in time. All this information was used to assess the level of implementation of adaptive co-management and policy learning. The interpretation of the results was facilitated by the fact that the first author has firsthand experience on the functioning of the Venice system having worked for 6 years in the role of member of the technical secretariat of the *Ufficio di Piano* (UdP). This is a technical committee advising the national government on priorities to safeguarding Venice and its lagoon from a physical, environmental and socio-economic perspective. The first author performed participatory observation, in the sense that she was involved in the preparation of and

attended all 675 UdP meetings from October 2004 to December 2010; this including those (about one third) to which experts (policy-makers, practitioners and scientists) were invited to report on specific issues regarding the safeguarding of Venice. She also had informal meetings (where she could ask questions) with the members of the committee and the experts invited to report at the UdP. Finally, she was involved in the drafting of all the UdP advisory documents and thematic reports. Most of this information (minutes, notes, presentations) is confidential and could not be directly used for quotation in this study. We did use the UdP advisory documents and thematic reports which are publicly available.

Then, we addressed the third research question by linking the level of learning we found with the implementation/non implementation of the adaptive co-management prescriptions. By doing it, we could draw recommendations on how adaptive co-management could help improving learning in the system. When possible (i.e. data were not confidential) we used quotations to support our findings.

4.3 The Venice lagoon system

The Venice lagoon is the largest coastal lagoon of the Mediterranean region. About 60 km of sandy coast line separate the lagoon from the Nord Adriatic Sea. Three inlets allow exchange of water with the sea (see Figure 4.1). An intricate network of rivers, streams and artificial channels spanning on about 2,000 km^2 of catchment basin ensure the inflow of freshwater into the lagoon through several estuaries. About 87% of the total 550 km^2 lagoon surface is open to the tide, with the closed surfaces occupied by fish farming. Land covers about 8% of the lagoon and is spread over more than one hundred islands, coastal strips, reclaimed land and banks.

The lagoon has a great variety of ecosystems (Torricelli et al. 1997; Ravera 2000). Typical coastal and marine environments such as beaches and dunes stretch along the littoral strips. Salt marshes, mud flats and shallows cut by a dense network of tidal creek characterize the brackish lagoon basin, particularly the northern lagoon and the central-southern internal edge. Sea grass meadows grow on deeper lagoon beds, mostly along the coastal strips, near the inlets. Typical fresh water environments colonized by reed and cattail are commonly found along waterways and rivers estuaries flowing into the lagoon.

The world-famous city of Venice is located at the heart of the lagoon. The magnificence of its architecture and art and the natural environment that support it have been recognized by UNESCO which included Venice and its lagoon in the World Heritage List in the year 1987. The second biggest center is the historical city of Chioggia in the southern lagoon, which has a small commercial port, a large fishing fleet and a beach area. Next to Venice and Chioggia, many islands and the littorals are inhabited. The population in the lagoon, however, has been declining since the late 1950s. At present, the historical center of Venice has about 60,000 inhabitants, down from 170,000 in the 1950s (Venice Municipality 2010). Inhabitants mostly moved to the nearby mainland, in the cities of Mestre and Marghera that are part of the municipality of Venice (see Figure 4.1). Since the 1930s Marghera has a chemical and petrochemical industrial area ("Porto Marghera") and an industrial and commercial port, which has grown to about 2,000 ha. Nowadays the area is heavily contaminated, some industrial plants have been abandoned and a cleaning up plan is being implemented under the responsibility of the Ministry of the Environment. The commercial port activity in, instead, expanding. Outside the cities, agriculture is the prevailing use of land in the catchments basin.

Figure 4.1 The Venice lagoon, its catchment basin and the near-shore for planning purposes (yellow line) and the location of the city of Venice, Mestre and Porto Marghera

Source: (Regione del Veneto 1999)

Humans, water and nature are profoundly interrelated and influence each other to a great extent in the Venice lagoon (Ravera 2000; Mag.Acque-Thetis 2006a; Rinaldo 2009). Nowadays, morphological instability and water level variation represent the two major threats for the physical survival of the lagoon. The lagoon morphology depends

on the equilibrium between the amounts of solid material brought by the sea and the rivers and the erosive forces of waves and tidal currents inside the lagoon basin. The diversion of the major rivers and the reconfiguration of the inlets morphology (started in the 16th century), the dredging of deep navigation channels in the 20th century along with wave motion and modern clam harvesting techniques have caused severe erosion and the progressive transformation of the lagoon into a marine environment. In the last decades alone, the surface area of the salt marshes (typical lagoon morphological structures) has been reduced by one third (Mag.Acque-Thetis 2006a). Water level variation in the lagoon is a phenomenon driven by tides and storm surges occurring mainly between November and February. Due to natural and human induced subsidence and sea-level rise, frequency of high waters that flood more than 10% of the city of Venice (up to 99%, depending on the event) has increased from 1-2 times a year to 8-10 times a year. Each high water event floods the lagoon urban centers for a few hours causing damage to the economy, discomfort for inhabitants, and degradation of urban infrastructure.

Human activity in the lagoon and wider basin (i.e. industry, fishery, commercial and industrial port, agriculture and tourism) is responsible for contamination, ecosystems deterioration and degradation of the historical city of Venice. High waters are major source of urban degradation which is visible in the aging of historical buildings foundations, bridges and urban infrastructure (Cecconi 1997). The loss of typical habitat and biodiversity is the major consequence of the construction of touristic infrastructure on the coast, clam harvesting techniques and motorboats transit (Mag.Acque-Thetis 2006a). At present, climate change is considered one of the possible major drivers of the future alteration of the lagoon ecosystem and of more frequent high waters in the city of Venice (Sestini 1992; Cecconi 1997; Mag.Acque-CVN 1997; Mag.Acque-Thetis 2006a).

National and local governments have been addressing the safeguarding of Venice and its lagoon, i.e. human safety, urban degradation and environmental deterioration, since the early 1970s. At that time the Italian government established a specific safeguarding regime known as the Special Law for Venice (Amorosino 1996, 2002; Bevilacqua 1998). The regime set objectives, responsibility, instruments, measures and economic resources for carrying out safeguarding activities in Venice. Major goals were the protection of urban centers from floods, the protection of coastal strips from erosion and sea storms, the re-establishment of the hydro-geo-morphological equilibrium of the

lagoon, the abatement of water pollution both in the catchment basin and the lagoon basin, and the promotion of socio-economic development of the historical lagoon settlements (Italian Republic Law n. 171 of April 16th, 1973; Italian Republic Law n. 798, November 29th, 1984). An integrated system of storm surge barriers at the inlet and local defenses (i.e. raising public pavements and restoring banks) to protect the urban centers from high waters are two major infrastructural works under construction.

At the national level, the Ministry of Infrastructure and Transport is involved in the management of the lagoon through its local branch, the Venice Water Authority. Dealing with water management and navigation control in the lagoon since 1907, the Authority is also in charge of the planning and execution of most safeguarding works delegated by the Special Law (Law n. 171 of 16 April 1973; Law n. 798 of 29 November 1984; Law n. 139 of 5 February 1992). Works are carried out by a private concessionaire of the Ministry of Infrastructure and Transport, named "Consorzio Venezia Nuova" (CVN). The CVN is building the storm surge barriers, the local defenses and the coastal defenses. It also implements a plan for morphological restoration including reconstruction of morphological structures and natural habitats. Scientific studies and systematical monitoring of the lagoon environment are also part of the CVN activities.

The Special Law implies that the Veneto Region, the Venice Municipality, the Chioggia Municipality, and the Safeguarding Commission for Venice are involved in the management of the lagoon. The Veneto Region is in charge of abating water pollution in the catchment basin of the lagoon. This is an area of 2,000 km^2 counting 4 provinces, 108 municipalities (including the Venice and Chioggia Municipality) and more than 1 million inhabitants. The region allocates the Special Law funds to local authorities (e.g. municipalities, water bodies, land reclamation consortia) in the territory of the catchment basin. The Venice and Chioggia municipalities are in charge of the maintenance of historical, cultural, architectural heritage and of supporting local socio-economic development, even through their own private companies. Finally, the Safeguarding Commission for Venice expresses its binding advice to project developers and approving authorities on all building works and territorial transformation planned by private and public bodies within the Venice lagoon. The committee still operates although it should have ceased its activity after the regional plan for the safeguarding of Venice had been approved.

Decisions about major safeguarding works and allocation of financial resources are taken by an Inter-ministerial committee (*Comitatone*) in which also the regional and local governments are represented. In 2004, the Italian government decided to support the Comitatone with a technical advisory Committee, called *Ufficio di Piano* which is a mixed committee of national and international experts and local policy-makers. To increase the effectiveness of some interventions, the administrations implement joint actions through specific inter-institutional legal agreements. From 1984 to 2009 the government has allocated about 10.2 billion Euros to achieve the safeguarding objectives, of which 8.8 billion Euros have already been spent. It is now assessed that another 6.1 billion Euros are needed to enable the completion of the safeguarding activities as intended at the time the Special Law regime was passed (Ufficio di Piano 2010a).

Beside the Special Law regime, the Italian Water Law (Law n. 183 of May 18th 1989) established regional water boards. Because the water law saved the competences of the Venice Water Authority, the Alto Adriatico water board that comprises five river basins including Venice does not have authority over the lagoon. The new law (Legislative Decree n. 152 of April 3rd 2006) transposing the EU Water Framework Directive (Dir. 2000/60/CE) changed the water governance system. The water boards are to be replaced with Water District Authorities having jurisdiction over much larger districts. In the interim, the water boards together with the regional administrations are responsible for the management of the water district. The Venice lagoon falls into the Alpi Orientali District that encompasses 13 river basins stretching over three regions and two autonomous provinces and two water boards i.e. the Alto Adriatico and the Adige. The Venice Water Authority competences over the lagoon are unchanged.

In the next sections we review to which extent this governance regime is in line with the prescriptions of the adaptive co-management, the extent to which learning is taking place, and what is the connection between the prescriptions and learning. In the section that follows, we analyze the extent to which the Venice lagoon management regime conforms to the prescriptions of the adaptive co-management literature, starting with the idea that governance regimes should be polycentric, and then moving to the issues of participation, experimentation and an approach at the ecosystem level.

4.4 Implementation of adaptive co-management in the Venice lagoon

The complex division of responsibilities and the extensive set of public and semi-public authorities involved in the management of the Venice lagoon suggest that the system indeed exhibits a certain degree of polycentricity in the sense that power is shared between many actors with overlapping responsibilities. Polycentricity is not only about the sharing of control; it is also about the freedom of local authorities to apply policies fitting with local preferences, and in this respect the system does not exhibit polycentric features as a national agency, i.e. the Venice Water Authority, and its concessionaire the CVN are influential actors in the system as they carry out major infrastructural works. Furthermore, for polycentric institutions to be effective wide cooperation is crucial. Also in this respect, the system does not exhibit polycentric features. Problems of leadership are claimed to exist; hierarchical approach to decisions and lack of trust due to long-lasting institutional disputes, in fact, lead to insufficient cooperation among public actors (*interviews: practitioners, scientists, public officers, April-June 2010*) .

By empowering the Venice Water Authority and the CVN to carry out most of the safeguarding works, the Special Law took away local power. In fact, although these two organizations are operating purely at the local level, they base their activity on the national agenda. They directly bring their project proposals and their request of funding to the national government via the Inter-ministerial committee. Although represented in the committee, the local authorities have not as much influence as the national authorities. More room exists for the Venice municipality to influence decisions within the Safeguarding Commission for Venice, which is made up of local experts. In this decision-making arena the municipality succeeded several times to make its position prevail. The commission, however, does not discuss all safeguarding works (e.g. some construction aspects of the storm surge barriers were not discussed here).

Orchestrating all institutions in the Venice system requires a lot of collaboration which is difficult to accomplish because governments have different levels of influence on decisions. The Venice Water Authority and its concessionaire are major actors. They successfully network within the national government but do not succeed to link with the local authorities and part of the community. Having a direct relationship with the national government contributed to an undervaluation the need to create local support to national decisions. In addition, as technical organizations made up and headed by technical expertise, their mission is to have safeguarding works done more than building

bridging and bonding social capital. In reaction to that, local authorities, particularly the Venice Municipality and several environmental groups, developed an opposing and sometimes ideological attitude towards most national decisions, the Venice Water Authority and the CVN (*interviews: public officers, practitioner, June 2010)*. The defensive strategy of the Venice Water Authority and the CVN and the offensive strategy of the Venice Municipality often turned into institutional disputes and into a major barrier to cooperation as institutional conflicts gradually eroded trust among actors. This long lasting situation impaired the possibility to build consensus over major safeguarding works such as the storm surge barriers. On the national political agenda since the mid 1980s, this project has always been opposed by the Venice Municipality, environmental and citizens groups and a number of local scientists. Their main objections focus on the threat to the lagoon's ecological balance and the high cost.

On top of that, a desire to streamline rooted in a hierarchical governmental culture (Arian & Barnes 1974 p. 601; Keating 1997 p. 393; Mack Smith 1997; Huysseune 2003 pp. 219-220) leads every public agency in the Venice area to claim leadership or greater control over the lagoon. The Venice lagoon is a unique case in Italy where a national governmental agency (the Venice Water Authority) has water management competences. Having water management competences in all its territory but the lagoon, the Veneto Region calls for complete water management control. On the ground of the safeguarding of Venice according to the Special Law, the Venice Municipality calls for greater freedom to decide safeguarding policies over its territory. In general, this attitude hampers cooperation and the possibility to attain more efficient environmental management.

Cooperation takes place to some extent in the Venice system. To deal with overlapping responsibility and jurisdiction, governmental agencies mostly use inter-institutional agreements by which costs of works are shared and official procedures simplified. This form of agreement is used not as often as necessary, however. Governments close such type of deals after long negotiations, only when there is a clear benefit for them and their authority is not questioned. Most inter-institutional agreements in Venice, indeed, reflect the need to "rationalize" the available resources and overcome complicated overlapping competences. One example is the Inter-institutional agreement of 3 August 1993 between the Venice Water Authority, Venice Municipality, Veneto Region on flood protection and urban infrastructure maintenance, the so called i.e. "integrated project" by which the Venice Municipality is in charge of restoring banks, building

foundations, bridges, utility shafts and raising public paved areas in the city of Venice (following the prescription of the Special Law n. 139 of 1992). Not all agreements like this are fully implemented despite the good intention to cooperate. The inter-institutional agreement of October 31, 2003 between Veneto Region and Venice Water Authority on environmental monitoring in the lagoon, the catchment basin and the near-shore sea is one of them. It established a technical board to coordinate and rationalize the water monitoring activity. The objectives were only partially achieved, being the two administrations able to rationalize the water monitoring infrastructure but not to unify the water monitoring systems under a single coordinating authority.

Turning to the issue of public participation, we can observe that there is no tradition of public participation and the decision making culture is not favorable to it (Dente et al. 2001; Giupponi et al. 2001; Giupponi & Brochier 2001; Sors 2001; Suman et al. 2005). Despite some progress in encouraging public involvement in decision making (also in fulfillment of EU requirements) past experiences did not produce successful outcomes (Sors 2001). According to Giupponi et al. (2001) factors contributing to this include the endless debate on Venice future, the complex decisional and institutional context, the high number of actors involved and the numerous conflicting interests. Findings of Dente et al. (2001) indicate that the public consultation process is dominated by environmental groups. This is a pity because other societal actors, however, also have a high level of awareness of local issues (Giupponi et al. 2001) and their participation in the management could be beneficial for understanding the functioning of the Venice social-ecological system. Another aspect that may discourage public participation is that the center of coordination for the most relevant safeguarding decisions is far removed from the local community. All meetings of the Inter-ministerial committee, in fact, have always taken place in Rome. The local authority called, without succeeding, for a meeting in Venice when the committee had to make important decisions in the past, for example about the storm surge barriers. Meeting in Venice would have been a signal of openness towards the local community (*interviews: practitioner, scientist, April 2010*).

Although in principle open to all relevant stakeholders, public participation regarding the safeguarding of Venice remains at the level of what Arnestein (1969) calls tokenism as participatory forums are not used a lot and most arguments brought forward by participants are commonly ignored. In this regard, the undergoing discussion about reforming the Special Law is the most recent example. In the year 2010 the national government appointed the Minister of Public Administration and Innovation to

coordinate the reform of the law. The Minister organized three rounds of meetings with stakeholders in July 2010. At each round he separately met (for about one and a half to two hours each) the institutional stakeholders (e.g. the Region, the Venice Water Authority, the local municipalities, the provinces, the Port Authority), and the societal stakeholders (e.g. industrial and tourism associations, labor unions, environmental groups). During the meetings the Minister illustrated his ideas for the new law and asked for written comments and suggestions to be send in a short time. He also launched an on-line forum on the issue. In November 2010, the Minister finally published the draft law on the web and presented it to the institutional stakeholders during separated meetings. For the public there was no more official forum for discussing the draft law. Environmental groups, economic associations, interested citizens therefore had to express their opinions through the local media. Recently, a group of citizens and environmentalists wanted to assist to the presentation of the draft law that the Minister was giving to the local authorities but they were not allowed because the meeting was only for the authorities (Mencini 2010). Looking at the Arnstein (1969) ladder of participation, all relevant stakeholders have been "informed" through public meetings and "consulted" through the opportunity to present written comments. Neither follow-up nor further information has been provided to them, however. In addition, it is not clear how and to which extent the different contributions have been considered in the draft law. Mechanisms to build consensus over different expressed preferences are also not clear. A three month process with only three short meetings plus written comments is, in fact, not sufficient to solve the complex issue of the governance of Venice. On the side of the civil society, the number of contributions (about 40) and the limited debate on the web forum are also indicative of the not yet established culture of public participation in the Venice system.

The fact that opportunities for interaction, representation and dialogue are so limited has a sad consequence in that a number of disagreements about decisions turn into conflicts and are subsequently brought to the courts. Initiators of court cases were almost always environmental groups whose comments had been disregarded; sometimes they were joined by other actors, most often the local authority. For them, the court is the last resource to try to have an influence on decisions, i.e. try to improve the quality of the decision. Sometimes, going to court is also a strategy to oppose decisions, for example by blocking works (as long as a case is in court policy effects/actions are suspended) (*interview: practitioners, scientists, April 2010*). This attitude shows unwillingness of

actors to compromise, which often may be disadvantageous. The case of the storm surge barriers is emblematic of the described situation. During the years, environmental groups (often joined by the local municipality) have presented nine appeals (all rejected) against the construction of the barriers to the Administrative Regional Tribunal (TAR) and the Council of State. Since 2003 the case has also been brought to the attention to the European Court of Justice by WWF and other environmental groups for violation of the Bird and Habitat directives (dir. 79/409/CEE and dir. 92/43/CEE). In the year 2005 the court decided to open an infraction against Italy with the motivation that measures to prevent deterioration of the EU protected habitats were not sufficient. Finally, in 2009, the procedure was closed after the Italian government committed to fund a plan of compensation measures of about 200 million Euros and to have a third party monitoring the construction works. Environmentalists (and indirectly the local authority by joining the court cases) had always openly declared that bringing the case to the court was the only way to try to prevent the barriers to be constructed and, after works started, to stop the works (about the latter, they partly succeeded as during the trial with the EU, the works had been stopped for about one month). Environmentalists and other local groups together with the local authority had never been willing to compromise their position even after the decision to build the barriers was made. This attitude led the local actors to lose important opportunities for including in the project changes that may be beneficial to the community. One of these is the possibility to use the underwater tunnels of the housing of the barriers to connect the littorals to the main land through a metro line. Now that the housings of the barriers are being constructed, making this change (if still possible) would be very expensive. If the actors had been willing to compromise during the past years, this change might have been introduced in the project at an earlier stage (*interview: public officer, June 2010*).

Interestingly, there are also some examples where stakeholder involvement has increased. In the late 1990s a co-management arrangement was initiated by the Venice Water Authority and the Venice province for the shell fishing sector. In the 1990s, free clam harvesting in the whole lagoon was causing serious environmental impacts (particularly erosion and disruption of eelgrass meadows). Therefore the local governments decided to deny the sector from free access to the resource to farming in granted areas. The governmental bodies engaged fisherman collectives in the decision-making process and the planning of the management of the resource. Although in this transition phase several operational problems have not found a solution yet, the adopted

approach resulted in having the regulation largely accepted. Indeed, about 1,350 fishermen entered into the circuit of which more that 50% was previously without fishing license (G.R.A.L. 2010). With this new policy the environmental impacts of clam harvesting are more under control. Illegal fishing, however, is still source of degradation of the lagoon. Despite this single case, as we have seen participation remains at the level of tokenism in the Venice system.

The third prescription we are interested in is experimentation. Experimentation as research methodology to provide scientific basis for environmental management is well established in the Venice system. In general, experiments are mostly confined to scientific domains such as water, ecosystems management and related technical and technological studies, whereas evaluation of policies (considered themselves experiments) is missing. Furthermore, the interpretation and use of knowledge is frequently questioned and politicized.

Whether experiments for environmental management lead to changing policies or not depends on the specific management sector. The morphological restoration and the reuse of sediment dredged from the lagoon channels for morphological restoration are two key examples of experimentation leading to different policy outcomes. Feedback knowledge from past reconstruction of morphological structures has been used to improve technical and operational practices. This innovation and new knowledge have been the foundation of the new morphological restoration plan under development (the final plan will be ready in 2011). Next to draw on past experiments, the whole process of revision of the morphological plan was an “experiment” itself in the sense that it was conducted differently from the previous plan. For the first time, in fact, a broad interdisciplinary group of local and national scientists covering different perspectives, especially on morphological models of the lagoon, was involved in the development of the plan. This led to the adoption of an ecological perspective in the reconstruction of morphological structures by integrating the morphological model with an ecological model. Not all scientists involved, however, are happy with the final plan. Some of them think that having involved a broad scientific community did not suffice to fully challenge the old approach to morphological restoration because a free flow of ideas was not always possible. The whole process of knowledge generation was controlled and results had to be processed and approved before being shared (i*nterviews: scientist, practitioner, April 2010*).

The reuse of dredged sediment for morphological restoration in the lagoon is, again on a scientific ground, an example where experiments and policy change do not go hand in hand. As a matter of fact, scientific knowledge has been accumulated much more rapidly than the policy system could absorb. The protocol of April 1993 among Ministry of Environment, Venice Water Authority, Veneto Region, Venice Province, Port Authority, Venice Municipality and Chioggia Municipality on environmental safety criteria for the excavation, transportation and re-use of sediment extracted from the Venice lagoon channels is a regulation that classifies dredged sediment in four categories of uses according to their level of pollution. The classification is based on standards of total concentration for a list of substances. On the one hand, there is an enormous need of sediment for the morphological restoration. On the other hand, according to this classification, most dredged sediment is slightly polluted (so called B category) and cannot be used for the morphological reconstruction and has to be safely stored at very high cost. In the past decade, several studies conducted by the Venice Water Authority and international scientists have proved that using this category of sediment for morphological reconstruction is safe and that it would be wise to revise the sediment classification using a risk assessment approach rather than standards. This would allow a more effective use of the lagoon sediment. All institutions that signed the protocol agree on the need to revise the regulation but not on the proposed approach to adopt (Ufficio di Piano 2010c). Consequently an evaluation of current safety norms has not been started and it is not facilitated by institutions at present. In particular, the main arguments of skeptics are that: the risk assessment approach is not completely objective; studies conducted by the agency that would most benefit from changing the protocol may be biased and therefore not reliable; the suggested approach is not in line with that adopted by the EU, which sets standards to assess sediment quality in the context of the WFD; the list of substances will have to be extended to be in line with the national and the EU regulation and therefore it may happen that changing the current norm would reduce the suitable sediment for morphological reconstruction (*public officer, personal communication, September 2010*). A new window of opportunity to start evaluating the current regulation comes from the monitoring program of the WFD. The monitoring will be conducted by different public agencies (i.e. it should be impartial) and will reveal the level of contamination of the lagoon sediment for a higher number of substances than those included in the protocol. If findings will support the results of the previous studies, the revision of the protocol might finally enter the agenda of the local policy-makers (*public officer, personal communication, September 2010*).

Thinking of policies as experiments and consequently adjusting them according to the level of attainment of the outcomes is not commonly done in the Venice system. The Special Law is the foremost example coming to mind in this regard. The establishment of the Special Law for Venice could be considered one major policy experiment (Dente et al. 2001). The governmental framework is grounded in a centralistic government tradition in which solutions are searched by experts on the basis of problems identified at political-governmental level and actions are based on inter-institutional coordination and rational planning (Dente et al. 2001). Whether this framework succeeded or not to achieve the safeguarding goals means evaluating its outcomes and impacts from a policy science perspective with the ultimate goal to revise the regime if necessary. The current process of reforming the Special Law is not based on such an evaluation, however. The closest example to an evaluation like that is the study of Dente and colleagues (2001) suggesting that the centralistic governmental system set by the Special Law has substantially failed, mostly because the coordinating institutions (i.e. the Inter-ministerial Committee and the Safeguarding Commission) add up to the decision-making process instead of simplifying it. The authors also suggest adopting a governance approach grounded on a shared vision of the future (Dente et al. 2001).

Interpretation and use of scientific results is an aspect of experimentation that is critical in the system. Examples of disputes about validity and interpretation of scientific knowledge range from the mathematical models for the representation of the lagoon system, to the possible solutions to prevent high waters and the typology and technology of the mobile barriers. Sometimes these disputes have also been politicized, particularly those regarding the mobile barriers. One major reason for this situation is that there is a high number of organizations generating scientific knowledge in the system (we counted nine) and no agency to coordinate resources, orienting research studies and evaluating research outcomes. An attempt to establish such an agency was not completely successful. The organization (called Co.Ri.La.) was established but does not have coordinating functions of the knowledge generated by the local agencies. It succeeded to channel national and European resources through a number of joint research studies to which local research institutes participated, however. The fact that research organizations most often act as possessors of data and information and generally lack confidence on each other scientific results contributed to partially fail this attempt.

Finally, we look at the bioregional approach as last feature of adaptive co-management. The first attempt to adopt a bioregional approach in the water management sector in Venice dates back to the sixteen century. At that time the Republic of Venice established the Venice Water Authority with water management responsibility over a broad territory to ensure hydraulic safety and navigation in the lagoon. Spanning from the Alps to the lagoon the territory included several watersheds influencing the hydraulics of the lagoon itself. After the end of the Republic (1797) the Venice Water Authority had its competences and covered territory changed several times. In the year 1907, finally it was re-established as local agency of the Ministry of Public Works (today's Ministry of Infrastructure) with water management competences over the lagoon of Venice and the watersheds related to its hydraulics. With the establishment of the regions in the 1970s the environmental management competences were gradually transferred to this level of government. This change regarded also the Venice Water Authority which passed the river management competences to the regions in the 1980s. To date its jurisdiction is limited to the lagoon basin and some areas outside. According to Rusconi (2002), the Venice Water Authority in its old configuration was a successful example of river basin management approach which was suggested to be extended to the whole country before the regions were established. He also argues that the fragmentation of the competences led to less effective hydraulic safety. Particularly, he points to important services that were unitarily provided such us flood control and regulation of water uses. Now that these services are supplied by different authorities, the limited available resources are spread on many small uncoordinated interventions instead of unitarily planned, thus reducing the overall safety of the region.

With the establishment of the water boards in 1989 the concept of management at a river basin scale entered the Italian law. The water boards, however, did not have formal decision-making power over the lagoon, that remained under the jurisdiction of the Venice Water Authority. In more recent times, the WFD officially brought the river basin management approach in the European countries. The transition towards the new river basin management system (see description in section 4.3) is, however, difficult. The establishment of a Venice sub-district including the lagoon, the catchment basin and the near-shore sea is hindered by issues of leadership, authority, tasks and responsibility distribution. In particular, the Veneto Region and the Venice Water Authority demand the leadership of the district authority in force of their current competences, territory covered, skills and knowledge. This situation has come to the

point that to comply with the EU deadline, these governments cooperated for the development of the water management plan but they could not agree on the governance issues and therefore the sub-district has not been established yet. In the interim the existing water boards will implement the plan in the whole district.

Now that we have analyzed the water and environmental management practices in the Venice system according to the prescriptions of adaptive co-management, we want to investigate the consequences of the implementation/non implementation of the prescriptions in terms of learning. To guide our analysis, we first conceptualize learning in the next section.

4.5 Conceptualizing policy learning

In this article we are interested in the learning that is taking place in the governance system surrounding the Venice lagoon. One of the key activities of the governance system is the production of policies that will steer its interventions in the ecosystem. Thus we are interested in policy learning, which we can define as "relatively enduring alterations of thought or behavioral intentions that result from experience and that are concerned with the attainment (or revision) of public policy" (Sabatier 1998).

Apparently, the distinction between different degrees of learning is useful as many authors suggest typologies on this basis. Most authors distinguish between a technical level and one or two "conceptual" levels at which learning can take place (cf. Foil & Lyles 1985; Hall 1993; Argyris & Schön 1996). Relevant here is the conceptualization of Argyris and Schön, for whom single-loop learning is "when a mismatch is corrected without changing the underlying values and status quo that govern the behaviors" (see Argyris 2003). Double-loop learning, by contrast, implies the mismatch being "corrected by first changing the underlying values and other features of the status quo" (Ibid.). The similarity between this type of learning and "moral development" (see later in this section) is obvious. Deutero-learning, finally, reflects on the institutional context for learning within an organization, and pertains, among other things, to the awareness that the organization needs to learn in the first place (Ibid.).

Within the literature, three critical aspects of learning have been identified, namely: who learns, what is learnt, and to what effect? (Bennett & Howlett 1992). The literature is fairly imprecise over what exactly is meant by these three aspects (Armitage et al.

2007). However, they provide a useful framework around which we can understand how learning in an appraisal process may lead to more reflexive critiques of policy goals.

As to the question about who learns, the basic distinction is between policy makers and societal actors. Some authors, such as Hall (1993), largely focus on the lessons that policy makers draw from their experiences, whereas others have shown greater interest in the way in which (groups of) societal actors, such as "advocacy coalitions" (Sabatier 1998) or "epistemic communities" (Haas 1992), learn, whether in interaction with policy makers or not. Obviously, the way the general public learns about policies is also relevant, but this is the topic of a different literature, the literature on agenda formation and agenda setting (see e.g. Wanta 1997; McCombs 2005).

As for "what is being learned," most writings on policy learning distinguish between different types and different degrees of learning (see Swartling & Nilsson 2007). Regarding the types of lessons learned, we can mention Webler et al. (1995), who suggest that there is a difference between the "cognitive enhancement" of parties, i.e. the acquisition of knowledge, and their "moral development", i.e. how individuals come to be able to make judgments about right and wrong. Others have pointed to the importance of what we may refer to as "relational learning." This type of learning relates to issues such as trust building, changes in the ability to collaborate, and changes in the ability to understand another party's goals and preferences (see e.g. Imperial & Hennessey 1999; Imperial 2005).

Table 4.1 Types of policy learning measured

Typology of policy learning	
Cognitive learning	Factual learning without changing underlying norms, values, belief systems
Normative learning	Learning encompassing a change in norms, values, and belief systems
Relational learning	Enhanced trust, improved understanding of mindsets of others

Source: (Huitema et al. 2010)

As to "what effect" policy learning is intended for, the overview of Bennett and Howlett (1992) suggests that most authors associate policy learning with policy change, in the sense that they only want to speak of policy learning in cases where policies have been modified or new policies have been adopted. In our opinion, this is a dubious assumption, for two reasons. The first is that policy change is often a result of other factors than policy learning. One can think of changes in government, bargaining between parties in the policy process, the emergence of powerful lobby groups, etc.

Secondly, even if policy learning does occur, it does not always express itself in the form of policy change, but may equally well result in a better foundation for existing policies. This could also be seen as a form of policy learning, as the evidence base for the current policy would have increased in such a case.

4.6 Exploring the level of policy learning in the Venice system

In this section we analyze the level of learning taking place in the Venice system. We focus on what is learnt according to the cognitive, normative and relational learning framework illustrated in the previous section and to who learns, i.e. policy-makers, scientific community and general public.

Cognitive learning takes place mostly within the scientific community in Venice. Large investments of national, regional and local governments in scientific research have led to improved environmental management practices (e.g. the morphological restoration, the storm surge barriers). Problem framing and solving are approached at a very technical and engineering level. Solutions consist of infrastructure with high technical and technological knowledge content (e.g. the storm surge barriers). Specialized experts, most commonly engineers coming with years of field practice, cover high level decision-making positions in the field of water and environment management at all level of government (e.g. water boards, Veneto region, Venice Water Authority, Venice province and municipality). The general public and part of the scientific community in Venice perceive this approach to environmental management to be too much technically oriented and lacking of an interdisciplinary perspective able to integrate the ecological and the social dimensions of the lagoon system (*interviews: practitioners, scientists, April 2010)*. Scientists, for example, call for a more integrated management approach of the lagoon not only limited to study the system for the purpose of infrastructural works. For the first time, the new morphological restoration plan actually goes in this direction by including an ecological perspective in the interventions.

Collective cognitive learning is limited due to lack of free flow of information and knowledge. Scientists and policy makers are generally not open to share knowledge with the public either because there is no culture of participation or because they are afraid of engaging in long-lasting discussion (*interview: practitioners, June 2010*). Opportunities for the general public to learn are restricted to information provided in the participative window of a number of decision-making procedures where participation is

required by law (e.g. water and nature management plans). In these occasions room for the public to bring its own knowledge about the system is limited to written comments, with a few venues for in depth discussion. Lack of resources also limits opportunity for the public to develop their own knowledge. Increasingly, collectives of citizens organize themselves to gather scientific information on the functioning of the lagoon ecosystem and on impacts of all ongoing infrastructures via non-institutional channels (interview: scientist, April 2010; Zanella 2010).

Policy-makers tend to learn from scientific evidence as long as this stays within the established paradigm. Whenever, the consolidated practice is questioned, lack of trust among actors instills doubts on the new scientific knowledge thus making cognitive learning difficult as in the case of the protocol on the reuse and disposal of dredged sediment in the lagoon.

Court cases seem to be one of the few options for the public, the scientific community and policy-makers to factual learning and to increase confidence on scientific knowledge. In court, in fact, the parties do their best to prove their arguments by bringing the most accurate, updated and complete scientific knowledge. In addition, the independent technical advice to the court brings additional knowledge that can help overcoming reserves about the parties' knowledge as it is independently generated.

Turning to relational and normative learning, we found little evidence. With reference to relational learning, we see that reciprocal trust and understanding does not improve and network relations do not evolve that much within and across the three groups. Some of the reasons for this to happen are that the governmental system is rather stable and not much open to new people; scientific knowledge is not fully shared; and court cases annihilate trust among actors.

The Special Law framework has shaped networks and coalitions in the field of water and environmental management for more than 30 years. Particularly, during the past ten years the system has been characterized by a lot of stability. High level policy-makers have not changed (e.g. in the Veneto Region, Venice Province, Venice Water Authority, Port Authority) or have come back into power (e.g. Venice Municipality). These people had time to develop and consolidate networks with policy-makers, the scientific community and the public over the years. They also built institutional memory in the field of environmental management. More recently, between the 2009 and 2010, in a very short time a number of these policy-makers either retired or was replaced. On the

one hand, institutional memory suddenly disappeared; on the other hand, a window of opportunity for new people to enter the governance system and develop new coalitions and networks opened. However, a number of these policy-makers did not leave the system but had a position in other local public organizations, therefore a real change did not occur and room for improving relational learning remained limited. New alliances seem to be emerging within this new configuration of governmental actors. These alliances may turn into more relational learning in the future. These new connections reveal a smart strategic reorientation of some governmental and private organizations. In particular, a new coalition among the Venice Municipality, the Venice Water Authority and the Port Authority has formed to support the construction of an off-shore petrochemical and container-ship harbor. The success of the Port Authority to revitalize this old project (it was already in the 1984 Special Law) can be attributed to its new leader and the broad national and international network that he built during his past political activity as mayor of Venice, minister of Infrastructure (to which the Venice Water Authority belong) and European commissioner for transportation. It is also interesting to note that since interests aligned on this project the historical political opposition between the Venice Municipality and the Venice Water Authority about the storm surge barriers seems no longer an issue. It is, however, too soon to say whether this new coalition will generate greater trust and cooperation among actors and therefore better relational learning. The fact that these new leaders have known each other for long time may, in fact, be a barrier to better understanding of reciprocal goals and preferences. The reaction of the general public to the emerging coalitions is something to expect too. So far the crystallized network of citizen's groups and environmental organizations and the scientific community seem not to have engaged in new pattern of relation with these actors. The environmental groups have started contesting the approach of "building massive infrastructure" as solution to multiple problems as soon as the project was presented.

Looking at the scientific community, in general, we found that collaborative networks and trust have not improved that much over the years. One reason is that part of the local scientific community still opposes the storm surge barriers in advanced construction. This, for example, is a barrier to a constructive discuss on the future management of this infrastructure. We have already mentioned a second reason, i.e. knowledge in the system is not fully shared. In this regard, some scientists considers the new morphological plan as a missed opportunity because the wide number of scientists

involved could not build much trust and increase understanding of each other knowledge due to a limited flow of information (*interviews: scientists, April 2010*).

The general public, in particular environmental organizations (but also scientists and policy-makers) have often missed the opportunity to improve their network and build trust within the system by taking disputes to the court. In court the parties learn how to place themselves in opposition to each other. This attitude demolishes trust, do not support reciprocal understanding and discourage cooperation. In this regard, court cases are missed opportunity to improve relational learning.

Finally, we also found little normative learning within the three groups. Among policy-makers it looks like old solutions are regenerated more than new ideas developed. Now that the discussion about the most controversial infrastructure, i.e. the storm surge barriers, has come to a resolution, the Venice Water Authority and the Venice Municipality have started changing perspective about the safeguarding of Venice. In recent times, they raised on the media the issue that two of the three goals of the Special Law can be considered achieved as most hydraulic infrastructural works are either completed or under construction and the environmental protection is in progress although there are some delays. Conversely, interventions to support the local economy have been inadequate to achieve the third goal of the law and need to be redefined. They therefore call for reforming the Special Law and set the new agenda which includes the construction of the off-shore petrochemical and container-ship harbor. Bringing up this idea now reveals the attitude of the local actors to solve problems by means of the same solutions, i.e. by building massive infrastructures which solve in one time several problems. In this case the new harbor will increase the port activity, local firms will have new work and the local economy will benefit from new jobs and businesses. In addition, although it was not the main priority, this project will increase environmental protection as taking the petrochemical ships out of the lagoon will prevent oil spill in the lagoon (the reason why the off-shore harbor was foreseen in the Special Law). The latter argument is frequently used by policy-makers to gain the consensus of the general public on this project. Local environmental groups, however, criticize the new perspective adopted for reforming the Special Law and this focus on major infrastructural works, calling for socio-economic incentives.

Looking to the public, normative learning seems limited by the culture of going to the court to solve disputes. By going to court these actors show unwillingness to question

their values and their reasons. They also do not engage in a constructive discussion as in court evidence is distorted, selectively treated and some information is left out. Another evidence of little normative learning is for example the fact that environmental groups still call the storm surge barriers off and use this argument in the debate about the future of the safeguarding of Venice. For, example, in the discussion about reforming the Special Law the environmental groups called for suspending the construction of the barriers and revising the project as priority before discussing any new work or change of the existing law.

Within the scientific community, lack of confidence in the scientific knowledge is a major barrier to normative learning. For years, part of the scientific community has questioned much of the scientific knowledge developed in the Venice system (e.g. mathematical models of the lagoon) arguing that it is not comprehensive and fully objective because it is functional to the infrastructural works (*interview: scientists, April 2010*). In more recent times, the willingness to challenge assumptions and values on which the morphological reconstruction is based has also been questioned by some scientists. Their argument is that, although an ecological perspective has been adopted for the first time, the interventions are not designed to support natural mechanisms of habitat conservation reflecting an old approach of framing problems and solutions (*interview: scientists, April 2010*).

Against this background, we conclude that there is not sufficient learning going on in the Venice system. Well established management practices and availability of resources allow a certain degree of cognitive learning within the scientific community. The fact that disputes are often brought to court is also an opportunity for factual learning but it does not encourage relational and normative learning. Within the scientific community and the general public relational and normative learning is also limited by the absence of a complete free flow of information and lack of confidence on scientific knowledge. Rather stable and close networks of relations among policy-makers, difficulty to share and trust knowledge and tendency to regenerate usual solutions are reasons for limited relational and normative learning among policy-makers.

4.7 Linking learning and the implementation/not implementation of the adaptive co-management prescriptions

In this section we try to establish causal link between the implementation of the adaptive co-management prescriptions and the level of learning we have found. We have summarized the main findings and pointed out the connections in Table 4.2. In the following, the analysis is organizes as much as possible around the four prescriptions of adaptive co-management, although there is a certain level of interference between the prescriptions and their consequences.

In our opinion, the degree to which the prescriptions on polycentricity and participation are followed dominate the relatively low learning levels we have found. The management system of the lagoon, although fragmented to a large degree, has clearly not been set up with polycentric governance in mind. The levels of local control over decision processes are too small for that, and the permeating design principle is one of top-down control, and management from the perspective of a limited set of goals (essentially building protective infrastructures). There are possibilities for participation but these have not really opened up the system to alternative voices as comments and criticisms are largely ignored. The management community can in this sense be compared to an epistemic community (Haas 1992) which is closed to outsiders and which works on the basis of an established paradigm, which must not be challenged. Outsiders, lacking a productive venue for entering debates, resort to the courts, where discussions normally focus on established positions and discrediting the contentions of the "opponents" (Huitema 2002). The degree of normative learning to emanate from a system like that is low, as was to be expected. The only possible exception to this finding is the higher importance of economic development on the agenda of those who have built the flood safety infrastructure. Here, we should probably be careful to apply the term learning however, as the developments that have happened here look relatively opportunistic and the changed priority of economic development for the Venice Water Authority (and the CVN) could easily be interpreted as an organization that has achieved its primary goal, but is looking for a new challenge and the same ideas can be applied. Constructing or expanding a harbor is obviously related to creating a large scale flood safety infrastructure and fits established lines of working, so this might actually be an example of a solution looking for a new problem (Kingdon 1995) rather than learning. However, as a consequence of the new agenda, former opponents are now starting to appreciate each other more, starting to collaborate, and new coalitions are

forged. Here too, the term (relational) learning might be overly complimentary as the new coalitions coalesce around established interests and do not emanate necessarily from new insights.

There is a certain level of experimentation going on in the system. This refers to experiments in a literal sense, meaning that physical interventions in the lagoon have taken place and their effects were evaluated thoroughly. As a consequence, new facts about hydro-morphology and the effects of reuse of contaminated sediment in the lagoon have emerged. These have affected policies to a certain degree, but it does appear that the policy system is lagging somewhat in the uptake of these insights. These experiments have not served as "boundary objects" that were able to draw multiple stakeholders to the debate about the lagoon, and their set up has been largely technocratic rather than participatory. There is no experimentation in the lagoon going on in the sense of "policies as experimentation", as the openness to alternative problem definitions or the arguing of alternative policy priorities is limited. The evaluation of the impacts of the storm surge barriers for example was carried out by a restricted and rather closed scientific community, in the first place. Then, when it was extended to a wider scientific community through the environmental impact assessment, the prescriptions were only partially considered (the assessment committee rejected the project, the judgment was then revoked by the court). This is one of the main reasons why different aspects of the project were brought to court several times. The effect of this on the learning levels is visible, as cognitive learning takes place, but it only takes place amongst those involved in said experiments and the experiments do not fundamentally challenge policy paradigms (as predicted by Fischer 1995). This is not only a matter of the way experiments are designed and the questions that drive them, it is clearly also influenced by the way the experiments are interpreted (as predicted by Huitema et al. 2009). In this case, the outcomes of the experiment with sediment disposal would change the power balance in the management of the lagoon and this is not acceptable to those that will have their influence diminished.

Finally, management at the bioregional level is what used to qualify the regime of the Venice lagoon, but with the advent of regional government in Italy, this situation has changed. It is interesting to observe how long the "institutional" memory from that period has lasted, to both the advantage and disadvantage of the management system. It has been advantageous in the sense that most people working in a fragmented set of water organizations still know their former colleagues well and they can therefore easily

reach for each other. The disadvantage is, however, that almost anybody working in the management system purports to provide “the” bioregional view, which means that there is actually contestation of authorities. This factor has complicated the implementation of the European Water Framework Directive, which is supposed to work with river basin organizations. In the Venice lagoon, the leading role in this process has not been decided. Effectively there is thus not much of active an operational basin wide management approach, but we have not been able to detect much effect on learning levels, except for the cognitive learning that results from the easy exchange of information between former colleagues. As this network of former colleagues becomes less dominant in the various successor organizations, the exchange of information across the basin might become more complicated as information is clearly also a strategic resource for those involved in the management of the lagoon.

The scientific community seems the only group learning from experiments although only within a shared scientific paradigm. Cognitive learning is more difficult to occur among the public and the policy-makers mostly because of no real participation, and insufficient communication and share of knowledge and experiments results among actors.

The little relational and normative learning we found in the three groups (scientists, policy-makers and the public) is linked to the little implementation of polycentricity and participation. Limited opportunities for actors to interact and the existence of a stable, centralized governance system keep actors disconnected and suspicious. Policy-makers, scientists and also citizens are split in coalitions that have been opposing each other believes and values in the formal decision-making arenas, in the court and on the media for years.

Against this background, we conclude that in general the water and environmental governance system in the Venice lagoon exhibits limited implementation of the adaptive co-management prescriptions. This has the consequence of a low level of learning in the scientific, policy-making and civic community. As predicted by governance scholars (e.g. Fischer 1995), cognitive learning in the scientific community is the only exception. As long as shared paradigm and experimental design is not questioned scientific knowledge and management practices keep improving.

Table 4.2 Adaptive co-management, learning and connections in the Venice system

Adaptive co-management prescriptions	Learning	Connections between co-management and learning
Polycentricity (-) • Highly hierarchical and mono-centric governmental system • National agenda and limited local power: leadership and authority claimed • Little incentive to public actors interaction • Official institutions meet and cooperate only when there is dependency (especially resource dependency) • Inter-institutional agreements are venues for interaction but used only in situation of dependency *Participation (-)* • No tradition of participation and decision-making culture is not favorable to it • EU regulation brought some formal participation • Participation as tokenism (Arnstein, 1969): public is informed and consulted but there is no follow-up, no mechanism to integrate public knowledge • Limited venues for participation generates frustration that turns into court cases • Public is not organized: environmental groups and other groups act often individually	*Cognitive learning (+/-)* • Established in the scientific community within a normative paradigm: well developed scientific and technical knowledge • Not well established in the policy-making and social community because: o No complete free flow of information in the system o Knowledge is not always trusted o Cases brought to court to stop policy effects or works, not for learning *Relational learning (+/-)* • Not well established in the scientific, policy-making and social community until recent times because of stable governmental system, with stable coalitions, not open to other actors • In the last two years change of a number of leaders in public institutions opened window of opportunity for new coalitions, new relations; too soon to tell if it will lead to relational learning • Not complete renovation, some instances of change of position and not arrival of new people • Loss of institutional memory with people left *Normative learning (-)* • Not well established in the scientific, policy-making and social community because:	*Polycentricity and learning* • Hierarchical mono-centric structure lead to overlook interdependency; therefore opportunities for interaction and cooperation are limited to the minimum, when dependency is evident. This lead to limited relational learning • The existence of coalitions that are more influential than other, the presence of a national agenda with a narrow mandate, and the existence of very closed networks hamper relational learning as there is no interest in meeting among actors • Lack of polycentricity leads to no reflection and no change of perspectives therefore no normative learning; *Participation and learning* • The frustration generated by the low level of participation do not incentive relational and normative learning • Going to court to suspend policy effects or works is a sign of unwillingness to all form of learning • Because of not complete flow of information in the system no cognitive learning of public *Experimentation and learning* • Experimentation taking place within normative paradigm allow cognitive learning but not normative and relational learning • Experiments are boundary objects to discuss things

Adaptive co-management prescriptions	Learning	Connections between co-management and learning
Experimentation (+/-) • Experimentation as research methodology has led to improve water and environmental management technology and practices (e.g. morphological restoration, mobile barriers) • Policies are not considered as experiments • Interpretation and use of scientific knowledge and experiments is sometimes politicized; validity and objectivity is questioned; knowledge is distrusted by actors *Bioregional approach (+/-)* • Water management at bioregional scale existed in the past through the Venice Water Authority; in the 1970s regions took over competences; now WFD re-establish river basin approach • Issues of leadership and authority claimed (Region vs. Venice Water Authority) hamper the transition to river basin management	o No complete free flow of information in the system o Knowledge is not always trusted o Disputes brought to court • Institutional memory may be an obstacle to change • Shift in policy agenda from physical and environmental protection to economic development is opportunistic because it does not bring new ideas and values but re-use old ideas for the system to work	together but it works only within shared paradigm, then no mechanisms to challenge values and allow new ideas and people to enter the discussion • The way experiments are designed and conducted affect how much they are trusted and therefore policy change *Bioregional approach and learning* • Past experience in river basin management led to build institutional memory as well as cognitive and relational learning to some extent because actors have worked together, created relations and knowledge*;* • Institutional memory about past experience of bioregional management limit normative learning as actors tend to act according to the memory they have about the system; institutions that used to rule the system, have knowledge and control still tend to act according to those values and beliefs • Collaboration and learning at bioregional scale occur if people expect it; if there is memory of one institution having control and knowledge relational and normative learning cannot improve • Dealing with existing coalitions and institutions become problematic when new institutions are created over a bioregion

Evaluation scale:
(-) limited; (+/-) to some extent; (+) present

4.8 Conclusions

In this paper we analyzed the level of implementation of the adaptive co-management prescriptions (i.e. polycentricity, participation, experimentation and bioregional approach) and we investigated the degree of cognitive, relational and normative learning taking place in a complex social-economic system, i.e. the Venice lagoon. We then searched for connections in the findings with the ultimate goal of identifying avenues for improvement in the governance of the Venice system.

The analysis suggested that the Venice system exhibits a limited degree of polycentricity and participation mostly due to a centralized, hierarchical government tradition lacking of a participation culture. Experimentation in the field of water and environmental management takes place only within the established scientific paradigm, while the adoption of a bioregional approach to water management suffers from issues of leadership, authority, tasks and responsibility distribution. We also found that there is not sufficient learning taking place within the scientific, policy-making and the civic community in the Venice system. Cognitive learning takes place mostly within the scientific community. Relational and normative learning are limited in all three groups because of difficulty to share and trust knowledge, existence of stable and closed actors' networks and a tendency to regenerate solutions. The fact that disputes are often brought to court is an opportunity for factual learning but it does not encourage relational and normative learning in the three groups. The degree to which the prescriptions on polycentricity and participation are followed dominate the relatively low learning levels we have found. Experiments as physical interventions have generated a lot of scientific knowledge but it appears that the policy system is lagging somewhat in the uptake of these insights. Experimentation in the sense of "policies as experimentation" does not take place. The institutional memory coming from the old times, when the bioregional approach was in force in the lagoon, makes officers relationship easier but also increases contestation of authority.

The methodological approach that led to the findings of this study proved to have both advantages and disadvantages. On the one hand, the involvement of the first author in meetings of the Ufficio di Piano may have introduced a bias towards either favoring or disfavoring the outcome. However, we think our perspective goes beyond the policy dominated views of the administrations and the government because the Ufficio di Piano is a technical advisory committee with a majority of independent members from

Italy and Europe that gained information from all different public and private organizations in charge of safeguarding Venice lagoon. On the other hand, the participatory observation gave the unique opportunity to gain a thorough understanding of the Venice formal and informal institutional system, which was crucial for the interpretation of the data. In addition to that, the fact that we could not interview environmental activists might be considered a limitation of our study. On this point, we think the abundant number of NGOs reports and articles we collected together with the newspaper articles allowed us to have a wide representation of the NGOs perspectives about the safeguarding of Venice. Most importantly, the refusal to engage in an interview by the environmental group was also informative for our study. We figured that they might not want to talk with people working for a public authority (i.e. the first author). This explanation is consistent with the findings of this study as it confirms the lack of trust of the citizenry in an institutional system that most often fails hearing the voice of the community.

The main conclusion of this study is that in the Venice system learning is mostly instrumental and limited to cognitive learning within the scientific community, whereas there is little relational and normative learning going on within the policy, scientific and civic community. This is mostly due to the existence of a system of central control that: inhibits participation and real polycentricity; makes it difficult to change policy in accordance to experiments results; and find it difficult to deal with problems at bioregional scale. Does the adoptive co-management have potential to change this situation? Providing opportunities for actors to interact can help improving all form of learning. Participatory experiences offer these arenas for interaction. Acting at bioregional scale also allows interaction as different organizations come to work together to achieve common goals. The same applies for polycentricity. A real polycentric system is highly cooperative meaning that there are many opportunities for actors to meet. Experiments, finally, can serve as “boundary objects” able to draw multiple stakeholders to the debate about the lagoon.

However, we advocate the relative value of following the ACM prescriptions. Armitage et al. (2007 pp. 6-10) recently pointed to the need for more insight on “conditions of adaptive co-management success and failure.” We, indeed, support the need to investigate more fundamental attributes which are pre-condition for the ACM to take place and be effective. The ACM framework, in fact, assumes certain social and cultural contexts which are not present everywhere. Making these conditions explicit would

allow prioritizing actions for ACM successful implementation. Focusing, for example, on what policy change is needed to make the governance system more polycentric would be no sense if the conditions to make that policy change to happen are not there.

The Venice lagoon case study is emblematic of this need to indentify and address the fundamental attributes that make ACM success. The analysis made explicit one of these fundamental attributes. This condition is trust and reciprocal respect among actors. In the Venice case the lack of trust among actors proved to be reason for limited communication and shared of knowledge and insufficient institutional cooperation which turned into insufficient learning in all societal groups. The Special Law regime seems to be at least in part responsible for this situation as it established a centralized, hierarchical governmental system that has kept actors disconnected. Together with knowledge and experience, actors in Venice have developed resentment and mistrust for each other over the years under the Special Law regime. Stable patterns of people engagement have developed from these feelings that have crystallized in closed coalitions and networks that make policy change difficult. In general, there is a problem of social capital which is not sufficiently developed also because there might be an interest in keeping people disconnected. Disconnected people do not easily succeed to be heard and to provoke substantial policy change. There are also cultural elements that prevent for example successful participatory experience.

It is clear that building trust again in the Venice system is a pre-condition to any policy change. In this regard, windows of opportunity open when a change occurs in key positions in the governance systems (if it is not just “musical chairs”, i.e. shuffling the same people among various locations). The advent of new people is beneficial to the governance system as they carry their own networks (i.e. new people) and ideas and they do not have the burden of resentment and mistrust. In Venice the new configuration of public actors that have emerged in the last two years can be an opportunity to improve trust by creating new relations. By engaging in new patterns of relations the local actors may success to reform the Special Law and design a polycentric, participative and adaptive governance system dealing with problems at bioregional scale. We would recommend performing a comprehensive social, economic and environmental evaluation of thirty years of Special Law regime as foundation of this new regime.

In conclusion, at present there is little implementation of the ACM prescriptions in the Venice lagoon which turns into insufficient learning (particularly relational and normative learning) within and across the scientific, policy-making and civic communities. The core problem is a lack of trust among local actors which need to be solved to make any policy change possible. Working on building trust is, therefore, a priority to pursue by all local actors in the years to come.

5 Summary of the results and reflection on the methodological approach of this research

5.1 Summary of the results of this research

Coastal regions are heavily human-managed ecosystems suffering from a number of problems generated by increasing population, overexploitation of natural resources and ecosystem services. Climate change is an additional challenge that coastal regions have to face nowadays. In particular sea-level rise is likely to exacerbate flooding, erosion, loss of ecosystems and damage and loss of economic assets. A balanced mix of *structural* (hard and soft infrastructures such as dikes and beach nourishment) and *non-structural* (policy, regulations, planning instruments, organizations and informational system) adaptation measures are needed to improve resilience of coastal systems and the adaptive capacity of society to cope with these challenges.

Because environmental policy decisions are increasingly a question of negotiation and agreement among stakeholders, a demand for governance arrangements able to create venues for interaction of actors and to support the emergence of actors' networks and coalitions has been raising in recent times. Tailor-made institutional reforms need to be developed to respond to the specificity of different regions as an ideal model of governance does not exist. Increasingly, governance scientists have pointed to the need to "identify salient features of a given situation and assembling these features to arrive at well-grounded conclusions regarding the basic character of the situation" (Young 2007 p. 10) in order to identify institutional reforms needed to improve effectiveness of given governance systems (what it is known and well established in the literature as the "institutional diagnosis" method).

Against this background, the objective of this research is to explore institutional arrangements for water and environmental management that would improve effectiveness in the governance of the Venice lagoon under conditions of climate change. Therefore, the core research question is: *how can governance arrangements for water and environmental management in the Venice system be reformed in a way that improves effectiveness in the context of changing climatic conditions?*

To answer the core research question a qualitative analysis of legislation and policy documents, assessment and evaluation studies, scientific literature and interviews is

conducted in three separated studies each of them organized as an individual article (chapter 2, 3, 4). In addition to that, I have firsthand experience of the functioning of the formal and informal institutional system at work in Venice. This experience comes from more than 6 years working as member of the technical secretariat of the *Ufficio di Piano,* a committee of policy-makers and scientists advising the national government on priorities for the safeguarding of Venice and its lagoon from a physical, environmental and socio-economic perspective.

The first article reflects on the ability of the non-structural and structural measures for flood protection to anticipate expected sea-level rise induced by climate change (chapter 2). Then, the second article looks into the institutions for water and environmental management to assess whether they support adaptive capacity of society to climate change. This analysis is done in comparison with another coastal region, the Dutch Wadden Sea with the aim of searching for lessons to be learnt (chapter 3). Finally, the level of implementation of the adaptive co-management as normative framework for effective governance and its implication in terms of learning are explored in the third paper (chapter 4). In the following paragraphs the findings of the analysis are summarized.

In chapter 2 it is made plausible that +60 cm SLR most likely expected by 2100 in the Venice region would significantly increase the frequency of flooding from current 8-10 times per year up to an average of 90 times per year (the data refer to the water level ≥ +110 cm a.m.s.l.). The uncertainty related to this finding is also highlighted. Non-structural and structural measures to protect the lagoon urban centers from flooding are then illustrated. Non-structural measures include the “Special Law for Venice” established in the 1970s. The law set objectives, national, regional and local authorities’ responsibility, regulations, measures and financial resources. One of the main goals of the Special Law was to protect Venice and the other lagoon settlements from flooding. For this purpose, an integrated system of storm surge mobile barriers and complementary measures at the inlets and local defenses in the urban areas are being constructed (structural measures). The barriers can withstand a rise in the mean sea level up to + 60 cm. Assuming that the anticipated government funding continues to become available at adequate level, the barriers and the complementary measures will be completed by 2014 and the local defenses in the city of Venice by 2030. The study,

finally, shows that the ability of these structural and non-structural measures to protect Venice from sea-level rise will depend on timely completion of all infrastructures for which a regular flux of financial resources is needed. It will also critically depend on the effective management of the storm surge barriers and the implementation of a novel environmental governance regime that takes climate change into account and encompasses the lagoon, its catchment basin and the near-shore sea.

In chapter 3, a tool called the Adaptive Capacity Wheel (ACW) is used to compare the adaptive capacity of institutions to climate change in the Venice lagoon and the Dutch Wadden Sea. The study has two objectives: first, to assess the adaptive capacity of institutions to climate change in each region; second, to search for lessons to be learnt by comparing the two cases. Relevant institutions for water and environmental management in the two case study areas are described and their ability to support adaptive capacity to climate change judged with the 22 criteria of the ACW (aggregated in 6 dimensions and in an overall adaptive capacity evaluation).

The analysis shows evidence of some adaptive capacity to climate change in Venice: a number of governmental organizations deals with water and environmental management in the lagoon; several regulations and services allow autonomous adaptation to flooding (e.g. an everyday tidal forecast bulletin); resources have recently started to be invested to generate scientific knowledge for climate; experimentation allows improving of technology and environmental management practices; hydraulic defense infrastructures are under construction and in general considered to be adequate to protect Venice from sea-level rise (which is viewed as the main problem in the long term) for the next one hundred years. However, the overall adaptive capacity of the institutional system for water and environment in the Venice lagoon is estimated as insufficient. Three main problems are identified.

- A lack of trust among local stakeholders is a source of insufficient cooperation, lack of confidence in scientific knowledge, and difficulty in sharing it. Open and constructive discussion of new ideas is difficult. Attempts to challenge the way strategies are defined do not fully succeed. Establishing an open dialogue about the future of Venice under conditions of climate change is challenging because there is no shared vision of the future, and adaptation goals have not been made clear.

- The governance system is fragmented and not coordinated at different governmental and spatial scales. A climate adaptation strategy for the whole watershed is not under discussion, and climate studies are carried out by different organizations separately. In their attempt to streamline all governments claim leadership of a single water and environmental management authority.

- The absence of a regular flow of resources to complete the safeguarding works, and of mechanisms to generate local resources for the maintenance of the infrastructure, is a key issue. Plans and programs not included in the Special Law often lack resources to be fully implemented.

In the Wadden, the analysis shows that the capacity to learn is a main strength of the institutional system. Other positive developments are the open dialogue in which many stakeholders are actively involved, and the increasing number of cooperative alliances forming in the Wadden area. New institutions like the Wadden Fund and the Wadden Academy play a role in these positive aspects. However, the overall adaptive capacity of the Wadden is estimated as insufficient. The following main problems with increasing the adaptive capacity in the Wadden Sea region are identified.

- The main debate in the region is not how robust present policies are in a timeframe of one hundred years, but rather how policymakers can cope with recent developments in the coming five years. Adaptation goals have not been made clear, and a shared vision on the future goals under conditions of climate change is lacking.

- Governance in the Wadden Sea region is fragmented and complex. While most stakeholders agree that laws should allow for more natural dynamics, and that governmental decisions should favour nature over economic concerns, no one seems prepared to take action, and everyone shifts responsibilities to other actors or levels.

- A structural lack of human resources, especially for enforcement of regulations and for nature management, may be an important barrier for improvement.

The comparison reveals that the two systems are similar in their natural aspects as well as in the patters of economic use and, consequently, also in the environmental pressures. Apart from some institutions deriving from the EU regulation, a very different pattern in the institutions governing the two systems is found. While the physical circumstances

are similar and the institutional setting is different, strikingly, the outcome of the analysis is again similar: neither of these two institutional systems has enough adaptive capacity to respond to climate change. Resources are a limiting factor for both regions. In Venice is more an irregular allocation of resources than the total amount that is source of inefficiency, while in the Wadden is a lack of human resources the problem. In Venice, lack of cooperation and accountability limit learning; institutions allow society a certain degree of autonomous change; a number of solutions are implemented to deal with climate change. In the Wadden case, learning is well established but lack of authority and leadership limits the decision making process.

In chapter 4, the level of implementation of four main prescriptions of the adaptive co-management framework is explored. The prescriptions are polycentricity, participation, experimentation and bioregional approach (Huitema et al. 2009). Then, as learning is the ultimate goal of adaptive co-management, the level of cognitive, relational and normative learning is investigated and related to the implementation of the adaptive co-management prescriptions. Finally, suggestions to make the adaptive co-management prescriptions operational are presented.

The analysis suggests that the Venice system exhibits a certain degree of polycentricity as power is shared between many actors with overlapping responsibilities. However, limited local power and insufficient cooperation lead to ineffectiveness in the system. Local control is limited by the fact that the Special Law for Venice has empowered a national agency, i.e. the Venice Water Authority and its concessionaire (the CVN) to implement most safeguarding measures. Cooperation among public actors is restricted to some sectors and actions because of problems of leadership claimed, hierarchical approach to decisions and lack of trust among public actors due to long-lasting institutional disputes.

With reference to participation, the analysis shows that despite some progress in encouraging public involvement in decision making, past experiences did not produce successful outcomes. This is mainly because there is no tradition of public participation and the decision making culture is not favorable to it. The fact that opportunities for interaction, representation and dialogue are so limited often turns disagreements into conflicts which are subsequently brought to the court.

Experimentation as research methodology to provide scientific basis for environmental management is well established in the field of water and environmental management. Interpretations and use of scientific knowledge is often questioned and sometimes politicized, however. Experimentation in the sense of "policies as experimentation" does not take place.

Management at the bioregional level is what used to qualify the regime of the Venice lagoon, but with the advent of regional government in Italy, this situation has changed. The bioregional approach is now back thanks to the EU Water Framework Directive. The transition to the new water management system is difficult, however. The establishment of a Venice sub-district including the lagoon, the catchment basin and the near-shore sea is hindered by issues of leadership, authority, tasks and responsibility distribution, with the Veneto Region and the Venice Water Authority claiming the leading role.

Revolving to learning, it is shown that there is not sufficient learning going on in the Venice system. Well established management practices and availability of resources allow cognitive learning within the scientific community. The fact that disputes are often brought to court is also an opportunity for factual learning but it does not encourage relational and normative learning. Within the scientific community and the general public relational and normative learning is also limited by the absence of a complete free flow of information and lack of trust on scientific knowledge. Rather stable and close networks of relations among policy-makers, difficulty to share and trust knowledge and tendency to regenerate solutions are reasons for limited relational and normative learning among policy-makers.

Finally, the investigation of the link between implementation of the prescriptions and learning reveals that the degree to which the prescriptions on polycentricity and participation are followed dominate the relatively low learning levels that were found. Experiments as physical interventions have generated a lot of scientific knowledge but it appears that the policy system is lagging somewhat in the uptake of these insights. The institutional memory coming from the old times, when the bioregional approach was in force in the lagoon, makes officers relationship easier but also increases contestation of authority.

The conclusion of the study is that in general the water and environmental governance system in the Venice lagoon exhibits limited implementation of the adaptive co-

management prescriptions. This has the consequence of a low level of learning in the scientific, policy-making and civic community. As predicted by governance scholars (e.g. Fischer 1995), cognitive learning in the scientific community is the only exception. As long as shared paradigm and experimental design is not questioned scientific knowledge and management practices keep improving.

5.2 Reflection on the methodological approach of this research

The results of this research are based on a number of data collection strategies and information sources. Reflecting on the fact that I participated in meetings of the Ufficio di Piano, it is important to report both advantages and disadvantages. Although the involvement may have introduced a bias towards either favoring or disfavoring the outcome, this was outweighed by the advantages. One of the advantages was that the working for the Ufficio di Piano gave the unique opportunity to gain a thorough understanding of the Venice formal and informal institutional system. Because the Ufficio di Piano is a technical advisory committee with a majority of independent members from Italy and Europe that gained information from all different public and private organizations in charge of the safeguarding of the Venice lagoon, my perspective goes beyond the policy dominated views of the administrations and the government anyway. In addition, my position facilitated access to different interviewees. The information obtained by interviews was supplemented with documental information. The policy documents allowed for a look into the (planned) future, whilst the legal documents helped identification of legal responsibilities. The interviewees were chosen such that different perspectives on the safeguarding of Venice were represented, and indeed different opinions were expressed. The use of peer reviewed scientific articles helped distinguishing between local preconception and scientific knowledge, particularly about climate change and the mobile barriers. Newspaper articles, then, ensured that I would not miss issues relevant to the general public and the public's perception of Venice governance and management issues.

This research has mostly focused on sea level rise and its impacts in terms of flooding in Venice. The Special Law regime, however, funds a number of different measures and the Venice lagoon can be affected by global warming consequences other than SLR. For example, increase of water temperature and changes in precipitation patterns are likely

to affect biogeochemical processes, lagoon water quality and salinity and therefore ecosystem functioning and biodiversity. A comprehensive assessment of the ability of all safeguarding measures to address different climate change impacts was beyond the scope of this study. Indeed, I believe it is required as baseline for adjusting the existing defense strategy in the long term.

For the scope of this study the Adaptive Capacity Wheel methodology was found to be useful. The set of twenty-two criteria proved to be a valuable tool because it helped creating a balanced overview of relevant aspects, and made it possible to compare the Venice case with another case in a structured way. The comparison between Venice and the Wadden, then, proved to be useful to identify lessons that the two regions could learn from each other. The physical and environmental similarities of the two regions and the rather different governance system allowed deeper understanding of possibilities to govern coastal regions. However, the tool had its difficulties. Firstly, interpretation of the criteria was not always straightforward. It would be helpful if the method was more explicit on how to interpret the different criteria. Secondly, the scoring process was difficult. Although there is no real solution to the subjectiveness of the scores, they can be made more robust by scoring in several rounds: first the main researcher, then colleague researchers who are knowledgeable about the studied area, and finally there could be a workshop with the respondents to discuss the scores. This will lead to adjustments and a better argumentation for each score. A dialogue with the respondents also serves the main purpose of the ACW, namely to detect possible weaknesses in the institutions and to discuss them with the involved governments and other stakeholders. The results of the study on Venice and Wadden were made more robust by a two round scoring process. First I did the scoring on the Venice case and the colleague did it on the Wadden; then the two of us discussed the results; finally, the results were discussed either with the respondents (in the Wadden case) or with one researcher and two practitioners knowledgeable about the governance system (in the Venice case). The process led to some review of the initial scoring, indeed.

As for the adaptive co-management framework the discussion is the following. As normative framework the adaptive co-management is helpful to diagnose a given governance system, i.e. to identify salient features and to and understand the basic

character of a situation with the ultimate goal of identifying institutional reforms needed to improve effectiveness (Young 2007). However, the relative value of following the ACM prescriptions is here advocated and the need to investigate more fundamental attributes as pre-condition for the ACM to take place pointed out. The ACM framework, in fact, assumes certain social and cultural contexts which are not present everywhere. Making these conditions explicit would allow prioritizing actions for ACM successful implementation. Focusing, for example, on what policy change is needed to make the governance system more polycentric would be no sense if the conditions to make that policy change to happen are not there. In particular, a certain degree of social capital, cooperation and trust among actors are fundamental to make adaptive co-management operational in presence of a number of public organizations having overlapping water and environmental management responsibility coexisting over a bioregion. Further theoretical elaboration on the adaptive co-management concept could, therefore, focus on the pre-conditions to make it operational. In particular, conditions and mechanisms to increase opportunities for interaction of actors so as to increase social capital and in particular trust are issues to further explore by adaptive co-management scholars.

Finally, some reflection is on the recommendations for the governance of the Venice lagoon. This research deliberately adopted a positivistic approach to knowledge and policy-making in making the recommendations. I am aware that reality is complex and decisions depend on people's opinions, values and beliefs to a great extent. The reason why I have taken this approach is to provide information that can help turning the current debate (which seems to have reached a stalemate) into a renovated discourse on the complex issue of the future of the Venice lagoon and its governance. My recommendations are, therefore, only suggestions of a possible way of viewing the future governance of Venice based on the analysis (from a social and policy science perspective) of the existing situation as result of past governance and policy decisions.

6 On the future governance of Venice and its lagoon

How can governance arrangements for water and environmental management in the Venice system be reformed in a way that improves effectiveness in the context of changing climatic conditions? In the following we address the core research question of this research by providing a number of recommendations that are derived from the analysis conducted and illustrated in the previous chapters.

Since humans have populated the Venice lagoon, water and environment have been managed to make the area livable. The result is a social-ecological system of great historical, cultural and natural value. In modern times, the existence of this social-ecological system is threatened by a number of natural and anthropogenic factors which cause erosion, loss of habitat and biodiversity, contamination, and urban degradation. Both the natural and the human built environment require large investments to be maintained and restored. The complexity of the human-environment relationship has led to increasing complexity of the system of governance over time, with a number of vertical and horizontal centers of government are in charge of water and environmental management in the lagoon and the catchment basis (see sections 1.2.4, 2.4.1, 3.3.2 and 4.3). This research has pointed out a number of key issues hindering governance effectiveness as result of this complexity. These can be synthesized in the following:

1. Lack of a regular flow of resources (see sections 2.5.1, 2.6, 3.3.3 and 3.6.1);
2. Lack of coordination of scientific knowledge (see sections 2.5.1, 2.6, 3.3.3, 3.6.1, 4.4 and 4.6);
3. Complex and non coordinated distribution of competences at different level of government (see sections 2.5.1, 2.6, 3.3.3, 3.6.1, 4.4, 4.7);
4. Lack of participation of stakeholders in the decision-making processes (see section 4.4, 4.6, 4.7).

The following sections will address these issues with some recommendations. By addressing these issues, the recommendations are meant to improve adaptive capacity of institutions to climate change, to build conditions for the implementation of adaptive co-management and improved learning, i.e. polycentricity, participation, bioregional approach, experimentation. All this would turn into greater effectiveness of the governance system in Venice.

6.1 A possible path for initiating institutional reforms in Venice

According to the findings of this research, in order to be able to deal with all the above mentioned issues, a fundamental precondition must be met: *trust* has to be built among actors in the Venice system (see sections 4.8). Trust is the *sine qua non* to improve effectiveness. One way to help building trust and to create a neutral and open arena for discussing the future governance of the lagoon is establishing a trustworthy, nationally supported, interdisciplinary "***Experts Committee***" in charge of advising a novel governance system of the Venice lagoon.

Setting up national committees to solve important political problems where the policy process is in a deadlock is common practice in the Netherlands and it has been done for the Wadden area (see section 3.4.2). Generally, Dutch policy-makers and citizens trust these committees and take their results seriously into account. Because in Italy there is no tradition of this sort, setting up such a committee may be difficult and its final advice may be disregarded. To ensure the process of such a Committee for Venice to be accepted by all stakeholders a chairperson must be found that is above all suspicions of being one-sided. Next to this, a professional **mediator** could be involved. Such a committee would first have to gain trust and consensus of stakeholder. Then the chair and the mediator could work on building a shared vision of problems and the future of Venice, discuss possible solutions and finally negotiate with stakeholders the appropriate alternatives to recommend.

The role of the mediator is to make sure that all governmental bodies are equally represented and have equal negotiating power and voice in the process. He or she also ensures that all relevant stakeholders' knowledge and perceptions are equally considered and evaluated in the process. Particularly critical is the issues of knowledge which in Venice has often been politicized (see sections 2.5.1, 2.6, 3.3.3, 3.6.1, 4.4 and 4.6). In order for all stakeholders to accept the recommendations of the committee, knowledge has to be trusted. This can be achieved by giving equal opportunity to all stakeholders to generate/provide their knowledge and to react on knowledge provided by all others. The committee will have to talk to all stakeholders and keep a transparent and permanent communication with all of them about scientific knowledge used and that left out.

There are a number of conditions that are required for this committee to function and achieve the goal of delivering sound and trustable advice. There conditions are:

membership has to be personal meaning that members do not represent any governmental body; it has to be clear on the mandate that the committee produces an advisory report and that the decision remains on the governments; the committee should be project organized with defined goals, resources and time frame to deliver the results (it is not meant to be a permanent body); it should report to the highest governmental level possible for this decision; it should be funded either entirely by the national government or equally contributed by all level of government; it should be based in Venice but not making use of any stakeholders' venue in order to ensure impartiality.

In Venice a mediation procedure would be a new approach to policy-making. Therefore, the decision to establish such an advisory committee supported by a mediator can only be made bottom-up. This means that first local governmental actors have to recognize that there is a problem of excess of authority claimed; lack of cooperative and visionary leadership; and not sufficient trust among themselves and between them and the society (see findings in sections 3.3.3, 3.6.1, 4.4, 4.6 and 4.7). They have to acknowledge these as the main reasons that do not allow dealing with the governance needs and the economic development of the lagoon at present. They also have to acknowledge the great interdependency among themselves and the urgency of taking actions. Then, they all together can call for the support of the national government to deal with the process of establishing and financing this committee. Financial support could be granted through the existing Special Law, for example.

The idea of an expert committee advising about the governance of the Venice lagoon resembles an already existing advising committee, i.e. the Ufficio di Piano (see sections 2.4.1). The Ufficio di Piano, however, presents some limits that would not make it in the best position to do this job at present. Firstly, the Ufficio di Piano mandate is not clearly defined as competences are only expressed in general terms. Secondly, although nominated by the national government on a personal basis (even if on suggestion of the local governments), some of the members tend to act according to the interests or views of the agencies they belong or that have suggested their membership. Thirdly, the local governmental authorities did not fully acknowledge the Ufficio di Piano mandate as they expected resolutions in line with their views more than objective scientific analysis. Over time, however, this latter attitude has slightly changed and the scientific contribution of the work of the Ufficio di Piano has gained greater consensus among local governments and stakeholders. Finally, the definition of the Ufficio di Piano agenda and the coordination of its activities are in the hands of a local agency which is

expression of the national government. For all these reasons, in its present configuration, the Ufficio di Piano does not fulfill the requirements above indicated for the experts committee.

Setting up an experts committee and a mediation procedure is one possible way forward. The work of the experts committee and the mediation process may take long, probably some years. The risk of failure should not prohibit such an effort to be made, as when actors hesitate to take the first step, it will only take even more time and problems will become more difficult to deal with. In the end, two main goals would be achieved with this approach: having actors to talk to each other and to slowly gain trust on each other work and knowledge (crucial for building up a common vision of the future and problems to solve); and achieving the maximum possible consensus among all stakeholders. The latter would prepare political decisions that a parliamentary majority will then support, through a new Special Law for Venice. The voice of a visionary, trustworthy leader embracing this approach as a policy experiment may facilitate to gain consensus and initiate the process.

6.2 Governance of the lagoon

Figure 6.1 sketches a possible configuration of the governance system for Venice and its lagoon that addresses the issues identified by this research and summarized in the 4 key problems at the beginning of this chapter. The scheme and relative recommendations are discussed in the following sections. The recommendations are meant to improve adaptive capacity of institutions to climate change, and to build conditions for the implementation of adaptive co-management and improved learning, i.e. polycentricity, participation, bioregional approach, experimentation. All this is intended to achieve the ultimate goal of improving effectiveness of the governance system in Venice.

6.2.1 Resources

The findings of this research point to the lack of regular and scheduled financial resources for the implementation of water and environmental management programs, to complete the safeguarding works, for the maintenance of the lagoon and of the urban structures (e.g. canal dredging, morphological restoration, historical buildings renovation, etc.), to implement adaptation measures, to generate scientific knowledge (including climate knowledge) and to conduct monitoring activities of the environment

and the climate. Not completing the safeguarding infrastructure or not performing regular maintenance works in the lagoon would bring additional costs in the long term and loss of competitiveness of some economic sectors in the Venice area (e.g. tourism, port activity, housing, etc.). An evaluation of these costs would justify the establishment of a "***Venice Fund***" and the identification of the subjects that should contribute to financing it and to what extent.

Money for the Venice fund could come from tourism revenues and commercial and industrial port revenues, for example. These two economic sectors, in fact, generate large private profits without paying for the externalities. Therefore, specific economic instruments may be designed for the purpose of financing the safeguarding activities and the maintenance. For example, making each tourist pay 1 euro/day for the maintenance of the city would roughly generate more than 24 million Euro per year (counting tourist presences and excursionists). Asking the shipping companies to pay 1 Euro per carried ton of goods passing through the port of Venice would roughly generate other 25 million Euros per year (which is the total tonnage shipped in the port of Venice in the year 2009). Unfortunately, local governments are afraid of creating mechanisms to make tourists, the tourism sector and the port companies pay for the externalities. This is because they are afraid of damaging these sectors and of losing local consensus which implies the risk for them of not to be elected again. As for the tourism, the main argument of the opponents, i.e. taxes would reduce the number of tourists and damage the tourist sector, in not supported by the evidence. The tourist demand for Venice is, in fact, rigid meaning that tourists are willing to pay a high price to visit the city. Only a strong and decisive action by local governments may allow raising this form of taxation. Because the national government is also involved in this decision the local government needs to prove vision, leadership and authority. Similar examples already exist in Italy (e.g. Rome). To increase efficiency, the International Private Fund Raising Associations for the Safeguarding of Venice could coordinate its spending with the Venice Fund. Next to that, close cooperation between the public and the private sector by means of the project financing for example, together with some national funding could provide the required resources for new major infrastructure, if needed. Keeping the maintenance of the mobile barriers separated from the fund would prevent a significant part of the resources of the fund to be absorbed every year. The national government could ensure the annual amount of resources for the maintenance (see also section 6.3).

Important issues that have to be discussed when establishing the fund are the board of the Venice Fund and mechanisms ensuring transparent procedures for spending these resources. The Fund may be managed by the Venice District Board (see section 6.2.3) or by an independent body. Both solutions have advantages and disadvantages. Having the Venice District Board to manage the fund would reduce institutional complexity but it would also reduce transparency of decisions. A periodical evaluation made by a third party would overcome this problem. An independent management body will have the advantage of ensuring transparency but it may also imply long procedures to have the availability of the funds. Choosing the members of the board is also critical as members have to be trustworthy and above suspicions of being one-sided.

6.2.2 Scientific knowledge

To improve learning (including on climate change issues) and institutional memory, ensure experimentation and bioregional approach this research pointed to the need to coordinate research and environmental monitoring efforts, develop pilot projects, encourage experiments, assess research and policies, allow free flow of information, and promote international cooperation. For this purpose, a ***"Venice Science Academy"*** could be established. Such an institute already exists and is called Co.Ri.La. It responds to the Ministry of the Education and Research and the local research institutes are members of the board. The institute did not fully achieve the goal of functioning as coordinator of the scientific knowledge for the Venice lagoon, however. It often succeeded to channel national and European resources through a number of joint research studies to which local research institutes participated. Other times, however, it was one of the research institutes competing for local, national and European research funds. The problem is that institute was formally empowered but then not fully legitimated by the research institutes to exercise its functions. The institute, on its side, was not able to be sufficiently authoritative to gain its space in the local arena. Indeed, legitimating is the first condition for the Venice Academy to work.

In the Wadden sea, such an academy is not a large organization because its main task is to connect existing knowledge institutes and to stimulate others to do research in the region (see section 3.4.2). In Venice, the Academy could have more ambitious tasks. Moving from the experience of the Co.Ri.La., the Academy could be a body for knowledge coordination, storage, sharing and communication. It could coordinate

research and monitoring activities regarding the lagoon, periodically assess and evaluate research and monitoring activities, ensure sharing of the knowledge among all research institutes, communicate knowledge to the public also by establishing/taking part to international networks.

By working in close relation with policy-makers (i.e. the Venice District Board, see section 6.2.3), the Venice Academy could establish a framework for knowledge production for the Venice lagoon balancing research needs for different disciplines (environmental science, economics and social studies) and time-scale (searching for solutions in the short vs. the long term). Within this framework, similarly to the EU research calls, the Academy could define research questions then make public calls encouraging joint application of different research centers, and choose the research consortia/project to be financed according to defined, transparent criteria. One of the first research activities to promote would be carrying out a climate change impacts assessment study of the whole Venice lagoon and catchment basin and develop a comprehensive adaptation strategy for the lagoon. Another one would be an evaluation of the outcomes of the Special Law regime from a social and economic perspective.

Fundamental tasks of the Academy would also be establishing common standards and procedures for monitoring, collecting and storing environmental monitoring data and supplying them when needed (e.g. for making tidal forecasts). Next to the environmental dimensions, it would be useful to understand and therefore monitor the social and economic dynamics occurring in the area in order to address problems in a holistic way. Next to that, establishing or connecting to existing national and international networks with the purpose of sharing knowledge, expertise and technology would benefit local actors and the local economy.

Assessing and evaluating research is an important means of learning. Periodical evaluation of knowledge generated, and its impacts in terms of policy change/improvement could be done by an independent agency in cooperation with the Academy.

Finally, communication of knowledge could take different forms, such as information and exhibition centers (some already exist and could be managed by the Academy), education campaigns, international promotion of scientific knowledge and technology, participation to conferences and scientific publications, promotion/support of the

establishment of international research centers offices in Venice, reporting to the authorities and to the public about progress and needs, etc.

At present the establishment of such an academy seems difficult as universities and research centers have to compete to obtain financial resources not only for doing research but also for their functioning.

6.2.3 Competences

The complexity of the governance system of the Venice lagoon was made clear throughout all this research. In particular, problems of leadership, authority, accountability and cooperation embedded in a conflicting and distrustful institutional atmosphere were identified as limiting factors to the adoption of a bioregional approach and source of little polycentricity as well as constraints to adaptive capacity. There are three possible paths that could be taken to address these issues.

1. Writing a "code of the lagoon legislation" re-designing governmental authorities and their responsibilities, based on an evaluation of the past experience. Such rational approach would be a policy experiment moving from past successes and failures. To be successful, however, this experiment requires a wide consensus of public and private stakeholders and large social support. At present these aspects are quite critical in the Venice system.

2. Establishment (by the national government) of one governing authority taking over water and environmental management competences currently allocated to different organizations. It would be a sort of Machiavelli's "benevolence prince" (Machiavelli 2005) taking good care of the future of the lagoon. This top-down approach has somehow already been experimented having the current Special Law empowered a national agency and its concessionaire to carry out major safeguarding works. One of the major consequences of this solution would be that there would be no polycentricity, which is one of the key attributes of an adaptive governance system. Multiple centers of control are supposed to be more resilient and better able to cope with change and uncertainty and therefore, more suitable in times of climate change.

3. Coordinating existing public authorities and competences over a wide territory including at least the lagoon and the catchment basin. This option would allow polycentricity, the adoption of a bioregional approach and would overcome

problems of authority and leadership claimed. The feasibility of this option, however, strongly depends on the level of trust among actors in the Venice system. Building the required level of trust may take long time.

The findings of this research suggest going for the third option, i.e. coordination of the existing competences. The lack of trust among actors together with the authority and leadership issues, in fact, neither allows a big change nor legitimating one powerful leadership. Small consensus based changes are more likely to occur over time through a guided process of trust building in the Venice system (which it was suggested in section 6.1 to be pursuit through an experts committee and a mediation procedure, see).

In this line of reasoning, establishing a "***District***" and a "***District Authority***" with coordinating functions seems a reasonable way forward. It could be a political body supported by a technical office. The Authority could be a renovated *Comitatone* established at local level in which all level of government and relevant public agencies are represented (State, Region, municipalities, water boards, etc.). The technical office could be a sub-division of the Venice Science Academy or a separated body dialoguing with the Academy. The advantage for the technical body to be part of the Academy would be having the possibility to build stronger connection between the scientific and the policy domains.

Establishing such a district is not a simple task. Issues of boundary and competences need to be thoroughly discussed among all relevant actors. There may be three possible options:

- wide competences over a wide territory;
- limited competences over a limited territory;
- "variable geometry".

A wide-competences-wide-territory approach would resemble the concept of "metropolitan area". In this case competences could span from water and environmental management to socio-economic development of a large area including Venice and its lagoon, the cities of Padua, Treviso and a number of other surrounding municipalities. The risk of not being able to deal with all problems of such a wide area is high. This configuration would, however, have the great advantage of being able to address

problems in a holistic way and therefore it is more likely that sustainable solution would be adopted.

A limited-competences-limited-territory structure would look like the existing situation under the Special Law regime, only restricted to water and environmental management issues. The existing boundaries would remain unchanged, i.e. the lagoon basin, the catchment basin and the near-shore sea. Governing the district without considering the economic activities influencing the water and environmental quality is, however, not possible. Therefore, networks and coalitions with other actors in the territory would have to be established to make sure the sustainability of the solutions adopted.

Borrowed from the language of mathematics and mechanical engineering, the term "variable geometry", brings the notion of adaptability and flexibility. In the Venice context, it would imply that decisions can be drafted with different amounts of flexibility for different groups of members or for changing circumstances. It basically implies variable boundaries and membership of the board. The composition of the board, the type of decision and the territory involved are different according to the subject at hand. For this system to function, clear and transparent rules and decision-making criteria are required which have to answer questions like who has to be involved according to the matter being discussed and who is in charge of decisions. In this form, the district authority may be a sort of *Conferenza di Servizi* (Conference of Services), a body meeting when needed, whereas the technical office may be a permanent body.

Whatever the district would look like, the District Authority should act according to a management plan. Moving from a long term vision of the lagoon, the plan may define a long term strategy and short, medium and long term objectives, actions and monitoring activities. It, for example, could establish a long term strategy for the maintenance of the city of Venice and the safeguarding works. The plan could be intended as an overarching plan for the management of the lagoon district and adopted by the Special Law. The relation with all other spatial and sectoral plan should be clearly stated.

The Authority would work in close relation with the Academy and would give permission to fund research through the Venice Fund. The technical office would bring the policy-makers' demand for knowledge to the Academy. The Academy would support studies and scientific research accordingly and would bring to the attention of the Authority new scientific evidence that may require policy responses.

To be effective, the District Authority needs to be legitimated and authoritative. Again, the role of the national experts committee and the mediation process appears to be crucial to build consensus on this initiative.

6.2.4 Participation

To improve participation in the Venice system, efforts need to be done by both the civil society and the governments. In Venice a number of citizens groups, environmental NGOs are active. Most often they are small goal-oriented groups (e.g. no-MOSE, no-cruise-boats, etc.) that know each other, sometimes gather together to discuss issues but most often they act independently from one another. This is one reason of difficult communication with policy-makers. Constituting a ***Forum for the environment***, an umbrella under which all these groups could unite, could give the possibility to these vices to be heard and to bring their knowledge in the system. The Venice Fund could financially support the forum as it happens in the Wadden Sea. In this way this platform would have the financial resources to pay its leaders, its own technicians, lawyers, and community organizers.

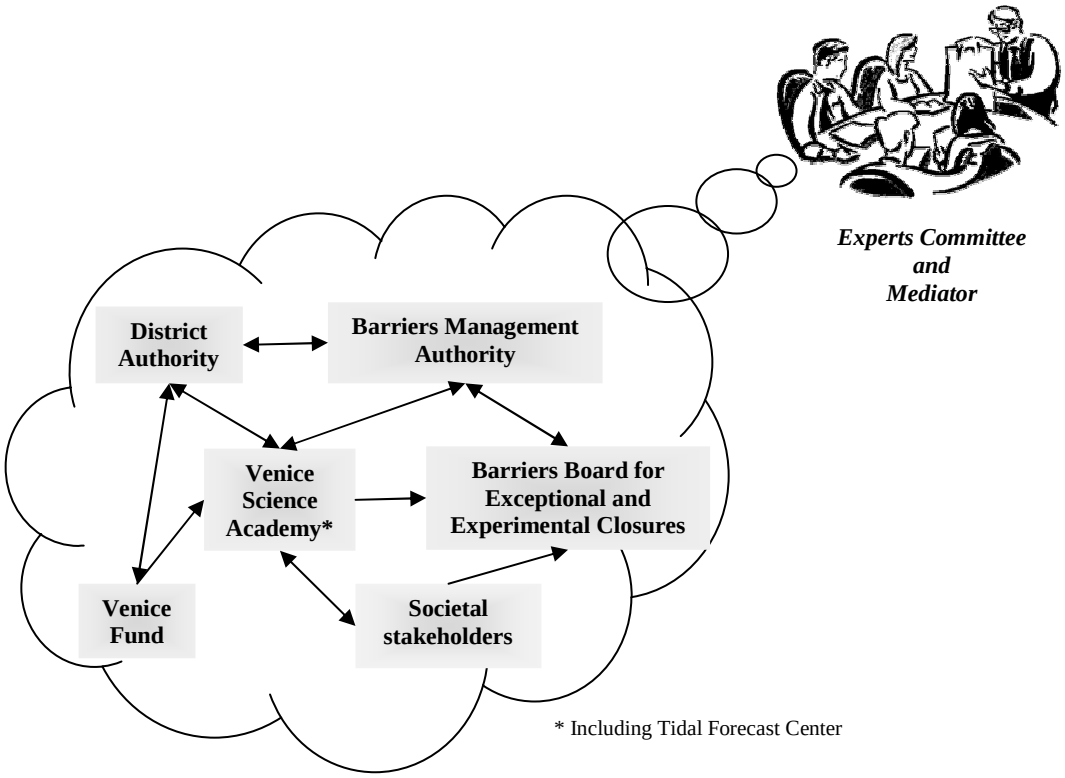
The same line of reasoning applies for the high number of interest groups that are also active in the Venice area. Industry, artisans, tourism associations and alike are dispersed and only the big groups have occasionally succeeded to give a constructive contribution to policy-making. Providing a platform for these groups to act conjunctly as in the case of the environmental groups may achieve the goal of reaching wide consensus on policy decisions and therefore willingness to accept policy effects.

Participation procedures could also be improved. For example structures enabling social actors to negotiate with power-holders such as joint policy boards or planning committees could be extended to a large number of decision-making procedures. Mechanisms for resolving impasses and to ensure that decisions are not subject to unilateral change are also needed. In addition, it is important that when social actors are engaged in a participative process, the process is completed and follow-ups are provided.

To allow participation of social actors to the design of the novel governance regime for the Venice lagoon, a Dialog Forum could, for example, be established and financially supported by the government. This entity would address all the questions raised in the public debate by the local community, the environmental groups and the economic

stakeholders. It would be an arena for consultation and clarification, as part of the ongoing debate and decision-making process for the design of a novel governance system for Venice.

Figure 6.1 Possible governance system for the Venice lagoon



6.3 Governance of the storm surge barriers

The governance of the Venice lagoon is linked to the governance regime that will be designed for the storm surge mobile barriers. The barriers will, in fact, operate tens of times every year as sea level rises. This will have consequences for the commercial, industrial and fishing port activity and for the environment. In addition, a regular flow of resources for the functioning and the maintenance of the infrastructure is needed. When designing the governance regime of the barriers a number of issues have, therefore, to be considered. These are:

1. Resources for the functioning and the maintenance of the barriers;
2. Criteria guiding the closure of the barriers;
3. Responsibility for the closing decision;
4. Possible use of the barrier to achieve environmental quality objectives.

In some international examples of storm surge mobile barriers such as the Thames barriers and the Rotterdam barriers, the national government provides the resources for the functioning and the maintenance of the infrastructure. Indeed, it seems reasonable that the Italian government would take responsibility of the functioning and the maintenance costs of the barriers as it has invested a great amount of resources to build them and it has set their construction as national priority. It may be wise to keep the maintenance of the barriers outside the sphere of competences of the Venice Fund, however. The Fund could be used to financing research, city maintenance and small scale projects.

As for the closure criteria, the Thames and the Rotterdam barriers do not provide useful insights. They do not have a high frequency of closure. The Thames barrier has been activated 80 times in the past 20 years and it is expected to suffice only until 2030. The Rotterdam barrier was used only one time since it became operational in 1997 and it is activated once a year for maintenance. In the future, due to sea-level rise the frequency of closure is expected to be one every five years. The closure decision and procedure is fully automatic and computer managed in both instances. A decision algorithm activates the closure procedure according to given criteria (e.g. the level of the water). A similar system in Venice seems not reasonable due to the much higher number of closures that can affect the regular functioning of a number of port activities, i.e. the commercial and industrial shipping, the fish fleet, the cruises. Although there are navigation locks, the closures may, in fact, slow down these activities. Therefore, a management strategy limiting the impacts on these activities is needed. In addition, the flexibility of the mobile barriers system in Venice allows using partial closures to improve water circulation or prevent sediment loss (see later in this section). These situations require to be dealt with by designing proper governance arrangements.

It seems practical that all relevant stakeholders would agree on a Barriers Closure Strategy which would look like a "code of the rules and of the exceptions" (*quote from one of the interviewees, March 2010*) to make the decision when and how (i.e. full vs. partial closure) to operate the barriers. There then would be a "***Barrier Management Authority***" in charge of the functioning and the maintenance of the barriers that would make the closure decision in ordinary situations according to the rules. Next to that, a "***Barrier Board for Exceptional and Experimental Closures***" coordinated by the Barrier Management Authority could evaluate the "exceptional closures". It would be a body meeting on demand of the Barrier Management Authority or of any other party

asking to make a decision out of the rules (e.g. the Venice Academy, the Port Authority). The Board may be a mixed committee of technical experts, policy-makers and relevant private and public stakeholders affected by the decision (e.g. the Port Authority, the trade unions, fishermen representatives, the cruises operators, water boards, land reclamation consortia, environmentalists, etc.). Situations the Board may be asked to evaluate are, for example, those when there is an important event in the city, the forecasted tide would affect the event but it is below the safeguarding level. It may also happen that the port authority or the cruises representatives ask for not closing the barriers at one inlet because of an intense shipping activity even if the expected tide is above the safeguarding level. Then, there could be a number of situations when the barriers would be closed or partially closed for environmental purposes (see later in this section). What should the decision be in these situations, respecting or not the rules? The answer depends on a number of conditions that the member of the Board would have to evaluate. All relevant stakeholders would have to negotiate all these aspects, hence an arena for evaluating the trade-offs of the exceptional closure decision need to be provided. The Board would be this arena, thus allowing to overcome disagreements. The Board could also have another important task to perform in close cooperation of the Venice Academy. It could in retrospect evaluate every closure afterwards, on a 6 months or one year basis and review the closure regime in view of the specific mandate of the Barrier Management Authority.

The code of the rules would set the safeguarding level, i.e. the water level at which closing the barriers. At present the level is set at 110 cm above m.s.l.. This value was adopted on the basis of a consultation of all local authorities. It was set considering the local defenses in place. Perhaps a lower safeguarding level will be needed as long as the local defenses in Venice and in the lagoon will not be completed (most likely not before 2030). This means that the number of closures will be even higher than expected for some time. Having a Board to make the decision for exceptional, additional closures is therefore essential in situations of already high number of regular closures. The code would also set principles and criteria guiding the closure decision in the ordinary situations. The precautionary principle could be stated as the foundation of the decisions, for example. This would imply that in case of uncertainty of the tidal forecast the barriers would be fully or partially closed even if the forecast is slightly below the safeguarding level. In this way the Board would not have to evaluate these situations of uncertainty of the tidal forecast. It could also be established that preventing the urban

centers to be flooded is always, under any circumstances the priority to pursue. The more the criteria are clearly and precisely set, the less the number of occasion in which exceptions are allowed and the evaluation of the Board required. The code would also specify when the decision is to be taken by the board, the composition of the board, the procedures to follow, what is an extraordinary situation, etc.

An important issue regarding the management of the barriers is the tidal forecast. A **Tidal Forecast Center** could be established as separated organization from the Venice Academy or as specific division of the Academy. The second option may be more advantageous in terms of effectiveness. The Academy would be, in fact, the organization in charge of collecting and storing all water and environmental monitoring data generated by the local research institutes. These data are needed to feed the tidal forecast models. The Academy then could also take responsibility of informing the population about the forecasted tide. The communication of the closure of the barriers to operators and the public then could remain on the Barrier Management Authority.

The more accurate and precise the forecast the less will be the number of false alarms. The accuracy of the forecast improves when the tidal event is approaching. Because the decision to close the barriers is not fully automatic but will also be made by the Board, it is necessary to establish the latest forecast to rely on for the decision and mechanisms to deal with false alarms.

Finally, besides the main purpose of flood prevention, the mobile barriers are an opportunity for innovative approaches to water and environmental management. As suggested earlier in this research (see section 2.6), using partial closures of the barriers would help improving the lagoon water quality and prevent loss of sediment at sea. Criteria for how and when to use or not to use the barriers for these purposes need to be defined. An experimentation protocol could be developed and implemented by the Barrier Management Authority, the Board and the Venice Academy. Because this way of using the barriers affect the governance of the whole lagoon the District Authority would need to approve the experimental protocol and probably in some cases it may be called to evaluate the decision to close the barriers.

The described governance system of the storm surge barriers in Venice would have the advantage of allowing flexible decisions according to the specific situation and minimizing disagreements among different stakeholders. It also would allow using the barriers in innovative ways.

6.4 Lesson learn for the governance of coastal regions in times of climate change

What can be learnt from the Venice case about how people living in coastal lagoons can govern in an adaptive way water and environment under changing climatic conditions? Climate change is a global challenge and the Venice lagoon is not an isolated example. Complex and bureaucratic governance arrangements are widespread especially in coastal lagoon areas and estuarine system. This makes coastal systems increasingly vulnerable to environmental change, like climate change may induce. The example of Venice shows that high level of technical and scientific knowledge and building infrastructure alone does not necessarily lead to the expected level of safety of the coast. Adaptation requires both structural measures such as soft and hard coastal protection works and non-structural measures such as institutional reforms to deal with increasing uncertainty and risk related to climate change. Building infrastructures seems relatively easy when resources are available. Setting up of adequate governance arrangements to manage these new systems does not always receive adequate attention.

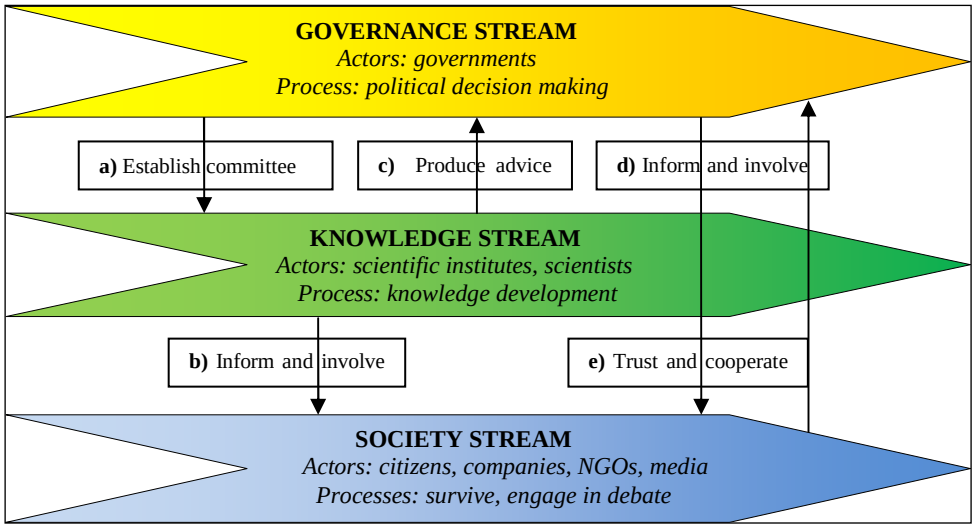
Governance of adaptation is a relatively new field in the social sciences that requires in depth understanding of cultural, social, political and environmental contexts. Above all it represents a new priority for policy makers, requiring a change in attitude to the political vision. Improvements can be obtained with a greater integration and coordination of institutions, knowledge, planning and management systems at all governmental levels. In particular, the need to strengthen local long-term planning mechanisms and establish cross-scalar institutions to support complex decisions is recognized when dealing with hard coastal defense infrastructure with long life span. A wide spatial vision at the scale of a bioregion is also important and implies cross-sector partnership at different administrative level and a share of responsibilities. Finally, adaptation is financial demanding in coastal areas; therefore mechanisms to make financial resources available are needed, such as reformulating scale of priorities and ensuring resources to existing programs that support adaptation rather than making new programs.

This research has shown that in Venice and in the Wadden Sea, institutions for ecosystems and environmental management limit adaptive capacity of institutions to climate change. This is a common finding in climate studies that reflects the difficulty to deal with uncertainty and risk that policy-makers face these days. Reforming

institutions, although taking long time, is crucial to increase the adaptive capacity of social and ecological systems. An ideal model of governance does not exist, however, and researchers need to develop a deep understanding of the context before searching for site specific solutions. In this regard, methodological approaches such as the Adaptive Capacity Wheel and theoretical frameworks such as the adaptive co-management are useful to diagnose the context with the aim of identifying possible solutions.

In general, when searching for solutions for governing global environmental changes and climate change specifically, the three streams model of policy processes (i.e. the policy, knowledge and society streams) may provide guidance (Kingdon 1984; see Figure 6.2). The processes within each stream should be managed in a constructive way while at the same time the processes in the other streams are kept in mind because they are interdependent. Progress can only be made when the policy, knowledge and society streams are connected in concrete actions, and each action between two streams can be expected to have an influence on the third stream as well, generating either less or more trust. Closely looking into these processes may help understanding how they interact and how it is possible to influence their direction towards improved water, ecosystems and environmental management.

Figure 6.2 The stream model of policy processes



Source: modified by Klostermann (personal communication) from Kingdon 1984

6.5 Conclusion

The findings of this research suggests that decades of studies funded by the Special Law for Venice generated technical and scientific knowledge and allowed building infrastructure that could make Venice one of the foremost regions adapting to climate change and an example from which other coastal regions could learn.

The integrated system of mobile barriers, local defenses and complementary measures being built at the inlets and in the urban centers can be considered adequate to protect the Venice lagoon for at least the next 50 years and beyond, given various SLR scenarios and expected high waters. This provided that the governance structure allows for timely completion of all infrastructure as well as proper management and maintenance.

The existing institutions for water and environmental management do not address these issues effectively, however. The governance system is fragmented and not coordinated at different governmental and spatial scales. A regular flow of resources to complete the safeguarding works and mechanisms to generate local resources for the maintenance of infrastructure and of the city is missing. A climate adaptation strategy for the whole watershed is not under discussion, and climate studies are carried out by different organizations separately. Above all, lack of trust among local stakeholders is source of insufficient cooperation, lack of confidence in scientific knowledge, and difficulty to share it. There is no shared vision of the future of Venice and open and constructive discussion about this topic is challenging due to the institutional stalemate.

If not properly maintained and managed and without ensuring the completion of all works, the whole safeguarding investment may fail to achieve the original goals. Designing the mobile barriers closure regime and a novel governance system for the watershed including the lagoon, the catchment basin and the near-shore sea would be first best. Reforming the current Special Law for Venice offers an opportunity to develop such a new regime with all relevant parties. Taking a climate change perspective in developing the new institutional system would then ensure long term protection from climate related risks. This research has indicated a possible path a number of institutions to improve effectiveness in the governance of the Venice lagoon.

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Estratto per riassunto della tesi di dottorato

Studente: Stefania Munaretto Matricola: 955405

Dottorato: Analisi e Governance dello Sviluppo Sostenibile Ciclo: 23°

Titolo della tesi: Governing Water and Environment in Times of Climate Change. The Case of the Venice Lagoon

Riassunto

La ricerca esplora strumenti di governo ambientale per migliorare l'efficacia della *governance* della laguna di Venezia in presenza di cambiamenti climatici. La ricerca inizialmente riflette sulla capacità di difesa dall'innalzamento del livello del mare delle misure di protezione dalle acque alte. Poi, valuta la capacità di adattamento al cambiamento climatico delle politiche per il governo dell'ambiente lagunare e lo fa comparando Venezia e il Wadden Sea in Olanda. Infine, valuta l'attuazione dell'*adaptive co-management* a Venezia quale strumento di efficace governance ambientale. L'analisi evidenzia come l'alto livello di conoscenze tecniche e scientifiche e le infrastrutture in corso di realizzazione collochino Venezia tra le zone costiere che meglio possono adattarsi al cambiamento climatico. Deve però essere assicurato un regolare flusso di risorse e strumenti di governo per il completamento delle infrastrutture, la gestione e la manutenzione delle opere di salvaguardia e della città. La riforma della Legge Speciale per Venezia offre l'opportunità di disegnare una nuova governance lagunare capace di rispondere a queste esigenze. Le raccomandazioni di questa ricerca offrono un possibile percorso per avviare la riforma e alcune ipotesi di strumenti per una più efficace governance della laguna di Venezia.

Abstract

This research explores institutional arrangements for water and environmental management that would improve effectiveness in the governance of the Venice lagoon under conditions of climate change. It, first, reflects on the ability of flood protection measures to anticipate expected sea-level rise induced by climate change; it, then, assesses whether institutions support adaptive capacity to climate change by comparing the Venice and the Wadden Sea (Netherlands); it, finally, explores the level of implementation of the adaptive co-management as framework for effective governance. The analysis suggests that high level of technical and scientific knowledge and the ongoing hydraulic infrastructure could make Venice one of the foremost regions adapting to climate change and an example for other coastal regions. This provided that the governance structure allows for timely completion of infrastructure and adequate management and maintenance by supplying regular funding and reforming the Special Law for Venice. Recommendations include a possible path and a number of institutions to improve effectiveness in the governance of the Venice lagoon.

Firma dello studente

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