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Facilitating transitions towards adaptive governance and management in estuarine socio-ecosystems: Institutional analysis and action research in the Doñana region

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Doctor by the University of the Balearic Islands

Facilitating transitions towards adaptive governance and management in estuarine socio-ecosystems: Institutional analysis and action research in the Doñana region

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The author

I certify that the present work is original, that all material in this thesis that is not my own work has been identified and properly referenced, and that no material has been submitted for which a degree has already been awarded to me.

Signed,

Pablo Fernández Méndez

The directors

We certify that this thesis has been developed by Pablo Fernández Méndez under our direction at the Mediterranean Institute for Advanced Studies (IMEDEA), a joint centre between the University of the Balearic Islands (UIB) and the Spanish Research Council (CSIC), and the Doñana Biological Station (EBD), a centre of the Spanish Research Council (CSIC), as a requirement for the award of a PhD in Biology: Earth and Environmental Sciences Speciality (based on UNESCO Nomenclature 2599).

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Universitat de les Illes Balears

IMEDEA CSIC

Estación Biológica Doñana CSIC

This thesis is dedicated to my family,
especially to my grandparents,
whose personal example and character have marked
my will to work hard into the unknown.

Antonio Fernández Rabaneda
In memoriam

"It is when the hidden decisions are made explicit
that the arguments begin"

G. Hardin (1968)
The Tragedy of the Commons

"Students frequently complain–and justifiably so–
that they have a sense of being in a Tower of Babel"

E. Ostrom (2005)
Understanding Institutional Diversity

"Suddenly, the resulting unpredictability stifles informed action
or triggers ignorant reaction"

C.S. Holling (2004)
From Complex Regions to Complex Worlds

Abstract

The accelerated impact of human activities is causing increasing damages to the Earth's life support systems. Consequently, the policy-making and scientific communities have advocated the urgent need for a change towards the sustainable use of natural resources and ecosystems. This thesis deals with the institutional conditions necessary for that change in coupled social-ecological systems, through an in-depth case study: the Doñana region, an estuarine social-ecological system affected by intricate water resources and wetland conservation problems located in the Guadalquivir Estuary (south-west Spain). In particular, I focus on the need for transitions from command-and-control schemes towards more flexible, participatory and adaptive approaches to policy and decision making: specifically, adaptive governance and adaptive management. For this purpose, I address three interrelated questions of broad research interest, using a theoretical framework that combines elements from resilience and institutional path dependence theories. The first question has implications for the implementation of participatory processes in the course of transitional designs towards adaptive governance and management, while the other two have implications at a theoretic-analytical level.

The first research question focuses on assessing the usefulness of an action-research program aimed at introducing adaptive management tenets at the research-management interface of the Doñana region (Chapter 4). The program, which paralleled an adaptive restoration in the context of the hydro-ecological restoration project Doñana 2005, combined a formalised process of networking, interviews, focus groups and System Dynamics techniques that proved useful to engage and build trust among a wide range of actors who finally participated in two adaptive management workshops. The participation of stakeholders and agencies entrenched in long-standing conflicts and power struggles up to that date was considered a major success of the program. During the workshops, the participants collaboratively developed a set of policy recommendations, offering potential avenues to improve the research-management interface, water resources management and wetland conservation practices in the Doñana region and Guadalquivir Estuary.

The action-research program was supported by preparatory research aimed at analysing the practices of, and learning from, best-in-class practitioners on adaptive management from British Columbia (Canada), where this approach was first conceived and implemented on a large scale (Chapter 3). Such preparatory research, which was based on a document review, interviews and a final workshop at the University of British Columbia (Vancouver), revealed that adaptive management has cycled, during the last four decades, through alternate phases of theoretical development, practical implementation and feedback, to which many scholars and practitioners have contributed. In particular, the workshop allowed current opportunities and constraints for the testing and implementation of adaptive management in Canada to be elicited, based on the direct, on-the-ground experience of practitioners and analysts. The results of that research provided the grounds and support for the strategic development of the action-research program in the Doñana region.

The preliminary identification, during the action-research program, of major rigidities within Doñana's institutional framework and management agencies triggered the second part of the thesis, which addressed, through institutional analysis, the two additional research questions mentioned above.

The second research question of the thesis focuses on enhancing the understanding of the roots of institutional rigidity in maladaptive social-ecological systems. Institutional rigidity that hinders change and smothers innovation represents a major constraint for adaptive governance and adaptive management. Therefore, to facilitate potential transitions towards more sustainable social-ecological systems characterised by adaptive approaches to decision-making, it is of utmost importance to understand and explain the origins of such institutional rigidity. In Chapter 5, by constructing a historical pattern, I identify the existence of a rigid institutional regime for water resources management and wetland conservation in the Doñana region, and explain, through a first theoretical iteration, the mechanisms underlying the genesis, amplification and persistence of such institutional rigidity. My explanation has two distinguishable parts: on one side, the deep-historical genesis of the regime at a critical juncture in the 19th century; and on the other side, the formation and continuity of the regime up to the last decades of the 20th century, despite its dysfunctionality for coping with crises and its inability to harmonise wetland conservation, water management and economic development. The historical

pattern confirms that the Doñana's regime has followed a path-dependent dynamic, largely characterised by the historical recurrence on the application of command-and-control schemes. In a seeming paradox, these schemes, instead of driving the regime towards an efficient outcome, led to the formation of a rigid institutional regime that drove the Doñana region into a sub-optimal systemic rigidity trap. This rigid outcome may be theoretically qualified as contingent, for it defies the traditional expectations of neoclassical economics that lie at the logical core of the concept of institutional path dependence.

The third research question of the thesis focuses on the explanatory potential of entrepreneurship and discourses, in their relationship with political-economic interests and power, as factors contributing to shape outcomes in local social-ecological systems. In particular, I discussed the explanatory potential of those factors, when the core logic of path dependence (composed by the mainstream principles of neoclassical economics) fails to predict observed outcomes in historical, evolutionary perspective, and qualifies such outcomes as contingent. In Chapter 6, I undertake a second theoretical iteration that re-examines the historical explanatory pattern developed in Chapter 5, in order to show how the Doñana's rigid outcome can be understood as more predictable. In particular, I argue that three mechanisms constituted necessary and sufficient conditions for the transformational process that led to the Doñana's rigid outcome: (1) a contextual political-discursive mechanism that mobilised power top-down and signalled increasing returns to actors downstream of the institutional regime; (2) the operation of increasing returns and self-reinforcing mechanisms bottom-up; (3) an endogenous entrepreneurial component that acted as a mechanism for action in an environment of extreme uncertainty.

In the general discussion of the thesis (Chapter 7), I make the case for systematising the role of discourses and entrepreneurship factors, in their relationship with political-economic interests and power, into the analysis. I argue that such systematisation contributes significantly to diminishing the degree of contingency associated to the Doñana's rigid outcome. More generally, my discussion deals with contingency as a property of the path dependence concept that can be modulated in explanations of institutional dynamics. This type of advancements could inform future policy and institutional designs for successful transitions towards adaptive governance and

management in social-ecological systems, hence improving the prospects for the sustainable use of natural resources and ecosystems.

Enriching the knowledge gathered during the action-research program with the in-depth analysis of institutional constraints rooted in historical factors, allowed a number of potential avenues to be identified that may aid the transition towards adaptive governance and management in the Doñana region (Chapter 9). It also allowed an informed speculation to be made about the potential role of action-research programs such as the one described in this thesis, to comply with (and complement) the requisites for public participation and social learning of European Union legislation: notably, the Water Framework Directive (Chapter 7, Section 7.4).

Key words: sustainability; adaptive governance; adaptive management; command and control; action research; rigid institutional regimes; institutional path dependence; neoclassical economics; contingency; resilience theory; adaptive cycle; discourses; power; politicised Institutional Analysis and Development framework; Doñana; Guadalquivir Estuary; Water Framework Directive.

Resumen

El impacto acelerado de las actividades humanas está causando el aumento de los daños a los sistemas de soporte vital de la Tierra. En consecuencia, gestores y científicos gestores han defendido la necesidad urgente de un cambio hacia el uso sostenible de los recursos naturales y los ecosistemas. Esta tesis trata sobre las condiciones institucionales necesarias para dicho cambio en sistemas socio-ecológicos, a través de un estudio de caso en profundidad: la región de Doñana, un sistema socio-ecológico afectado por problemas complejos en términos de recursos hídricos y conservación de humedales, situado en el Estuario del Guadalquivir (suroeste de España). En particular, en esta tesis me centro en la necesidad de transiciones desde estrategias de mando y control hacia enfoques más flexibles, participativos y adaptativos para la elaboración de políticas y la toma de decisiones: específicamente, gobernanza adaptativa y gestión adaptativa. Para ello, abordo tres preguntas de interés de investigación, amplias e interrelacionadas, utilizando un marco teórico que combina elementos de las teorías de dependencia de la trayectoria institucional y la resiliencia. La primera pregunta tiene implicaciones para la implementación de procesos de participación en el curso del diseño de transiciones hacia la gobernanza y la gestión adaptativas, mientras que las otras dos tienen implicaciones a nivel teórico-analítico.

La primera pregunta de investigación se centra en la evaluación de la utilidad de un programa de investigación-acción cuyo objetivo fue introducir principios de gestión adaptativa en la interfaz investigación-gestión de la región de Doñana (Capítulo 4). El programa, que se desarrolló paralelamente a una restauración adaptativa en el contexto del proyecto de restauración hidro-ecológica Doñana 2005, combina un proceso formalizado de networking, entrevistas, grupos focales y técnicas de Dinámica de Sistemas, que demostró ser útil para fomentar la confianza entre un amplio rango de actores que finalmente participaron en dos talleres de gestión adaptativa. La participación de partes interesadas y organismos que se habían visto anteriormente envueltos en situaciones conflictivas y disputas de poder fue considerada un gran éxito del programa. Durante los talleres, los participantes desarrollaron en colaboración una serie de recomendaciones de política, ofreciendo posibles vías para mejorar la interfaz

investigación-gestión, la gestión de los recursos hídricos y la conservación de humedales en la región de Doñana y el Estuario del Guadalquivir.

El programa de investigación-acción fue apoyado por una investigación preparatoria dirigida a analizar y aprender de las prácticas de profesionales líderes en gestión adaptativa de la Columbia Británica (Canadá), donde este enfoque fue concebido e implementado por primera vez a gran escala (Capítulo 3). Dicha investigación preparatoria se basó en una revisión documental, entrevistas y un taller final en la Universidad de la Columbia Británica (Vancouver), y reveló que la gestión adaptativa ha completado varias fases alternas de desarrollo teórico, aplicación práctica y retroalimentación durante las últimas cuatro décadas, a las que muchos académicos y profesionales han contribuido. En particular, el taller permitió extraer lecciones sobre oportunidades y limitaciones actuales para la implementación y evaluación de la gestión adaptativa en Canadá, basadas en la experiencia directa de profesionales y analistas sobre el terreno. Los resultados de esa investigación sirvieron de base y apoyo para el desarrollo estratégico del programa de investigación-acción en la región de Doñana.

La identificación preliminar de importantes rigideces en el marco institucional y las agencias de gestión de Doñana durante el programa de investigación-acción, motivó la segunda parte de la tesis, la cual abordó las dos preguntas de investigación adicionales mencionadas anteriormente, mediante análisis institucional.

La segunda pregunta de investigación de la tesis se centra en mejorar la comprensión de las raíces de la rigidez institucional en sistemas socio-ecológicos maladaptativos. La rigidez institucional representa un obstáculo importante para la gobernanza y gestión adaptativas, ya que impide el cambio y dificulta la innovación. Por lo tanto, para facilitar potenciales transiciones hacia sistemas socio-ecológicos más sostenibles caracterizados por enfoques adaptativos para la toma de decisiones, es de suma importancia entender y explicar los orígenes de la rigidez institucional. En el Capítulo 5, a través de la construcción de un patrón histórico, identifico la existencia de un régimen institucional rígido para la gestión de los recursos hídricos y la conservación de los humedales en la región de Doñana, y explico, a través de una primera iteración teórica, los mecanismos subyacentes a la génesis, amplificación y persistencia de tal rigidez institucional. Mi explicación tiene dos partes diferenciadas: por un lado, la génesis

histórica profunda del régimen en una coyuntura crítica en el siglo XIX; y por otro, la formación del régimen y su continuidad hasta las últimas décadas del siglo XX, a pesar de su disfuncionalidad para hacer frente a las crisis y su incapacidad para armonizar la conservación de humedales, la gestión del agua y el desarrollo económico. El patrón histórico confirma que el régimen institucional de Doñana ha seguido una dinámica dependiente de la trayectoria, ampliamente caracterizada por la aplicación recurrente de estrategias de mando y control a lo largo de la historia. En una aparente paradoja, estas estrategias, en lugar de conducir al régimen hacia un resultado eficiente, llevaron a la formación de un régimen institucional rígido que condujo la región de Doñana a una trampa subóptima de rigidez sistémica. Este resultado rígido puede ser calificado por la teoría como contingente, ya que desafía las expectativas tradicionales de la economía neoclásica que yacen en el núcleo lógico del concepto de dependencia de la trayectoria institucional.

La tercera pregunta de investigación de la tesis se centra en el potencial explicativo del emprendimiento y los discursos en su relación con los intereses político-económicos y el poder, como factores que contribuyen a la formación de sistemas socio-ecológicos a nivel local. En particular, centro mi discusión en el potencial explicativo de estos factores, cuando la lógica base de la dependencia de la trayectoria (compuesta por los principios dominantes de la economía neoclásica) fracasa en predecir los resultados observados desde una perspectiva evolutiva histórica, calificando estos resultados como contingentes. En el Capítulo 6, emprendo una segunda iteración teórica que reexamina el patrón explicativo histórico desarrollado en el Capítulo 5, con el fin de mostrar como el régimen institucional rígido Doñana puede entenderse como más predecible. En particular, sostengo que tres mecanismos constituyeron condiciones necesarias y suficientes para el proceso de transformación que llevó a la rigidez en Doñana: (1) un mecanismo político-discursivo contextual que movilizó el poder desde arriba hacia abajo e indicó rendimientos crecientes a los actores de los niveles operacionales del régimen institucional; (2) el funcionamiento de los rendimientos crecientes y mecanismos de auto-refuerzo de abajo hacia arriba; (3) un componente endógeno de emprendimiento que actuó como mecanismo de acción en un entorno de incertidumbre extrema.

En la discusión general de la tesis (Capítulo 7), presento argumentos para la sistematización, en el análisis, de los discursos y el emprendimiento en relación con factores político-económicos y de poder. Sostengo que tal sistematización contribuye significativamente a disminuir el grado de contingencia asociado a la rigidez en Doñana. Más en general, mi discusión trata sobre la contingencia como una propiedad del concepto de dependencia de la trayectoria que se puede modular en explicaciones sobre dinámica institucional. Este tipo de avances podría informar futuras políticas y diseños institucionales para una transición exitosa hacia la gobernanza y la gestión adaptativas de los sistemas socio-ecológicos, y, por lo tanto, para incrementar la posibilidad de gestionar los recursos naturales y los ecosistemas de forma más sostenible.

El enriquecimiento del conocimiento adquirido durante el programa de investigación-acción con el análisis en profundidad de las limitaciones institucionales arraigadas en factores históricos, permitieron la identificación de una serie de posibles vías que pueden ayudar a la transición hacia la gobernanza y la gestión adaptativas en la región de Doñana (Capítulo 9). Asimismo, este enriquecimiento permitió una especulación informada sobre el papel potencial de programas de investigación-acción como el que se describe en esta tesis, para cumplir con (y complementar) los requisitos para la participación pública y el aprendizaje social de la legislación de la Unión Europea – en particular, la Directiva Marco del Agua (Capítulo 7, Sección 7.4).

Palabras clave: sostenibilidad; gobernanza adaptativa; gestión adaptativa; mando y control; investigación acción; regímenes institucionales rígidos; dependencia de la trayectoria institucional; economía neoclásica; contingencia; teoría de la resiliencia; ciclo adaptativo; discursos; poder; marco teórico para el Análisis y Diseño Institucional politizado: Doñana; Estuario del Guadalquivir; Directiva Marco del Agua.

TABLE OF CONTENTS

Deliverables of the thesis

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Méndez, P.F., Isendahl, N., Amezaga, J.M. and Santamaría, L., 2012. Facilitating transitional processes in rigid institutional regimes for water management and wetland conservation - Experience from the Guadalquivir Estuary. *Ecology & Society,* 17(1), 26. [Online] Available at: http://dx.doi.org/10.5751/ES-04494-170126

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List of figures

List of tables

List of boxes

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Chapter 1. Introduction

1.1. The institutional challenges in the process of change towards the sustainable use of natural resources and ecosystems

In the so-called "anthropocene" (Crutzen and Stoermer 2000, Steffen et al. 2011), the increasing extent and impact of human activities are causing considerable changes in the climate and ecosystems, which include reductions in biodiversity, habitat loss, environmental pollution and the depletion of many natural resources (Dirzo and Raven 2003, MEA 2005, Steffen et al. 2004, Butchart et al. 2010). These pressures might increase the risk that environmental and ecological systems, and even the biosphere as a whole, go beyond thresholds indicating the shift towards undesirable alternative states less suited to maintain human welfare (Rockström et al. 2009, Westley et al. 2011, Barnosky et al. 2012, Biermann et al. 2012, van Zon and David 2013). Consequently, the need to make a change towards the sustainable use of natural resources and ecosystems has been advocated by the policy-making and scientific communities. In particular, it is argued that this change must include broad shifts in current governance, policy and management schemes, and a profound reconsideration of the dominant values, beliefs and patterns of socioeconomic development (see e.g., Brundtland Report 1987, Raskin et al. 2002, Loorbach and Rotmans 2006, Loorbach 2007, Chapin et al. 2009, Voß et al. 2009, Levin and Clark 2010).

The scope of my thesis (Fig. 1) is the investigation of the institutional conditions necessary for a change towards the sustainable use of natural resources and ecosystems in coupled social-ecological systems, an object of study that addresses specific relationships and problems among socioeconomic, institutional and ecological components (Berkes et al. 2003, Janssen et al. 2007, Anderies et al. 2004, Norberg and Cumming 2008). Here, I approach the investigation of those institutional conditions through an in-depth case study: the Doñana region, an estuarine social-ecological system affected by intricate water resources and wetland conservation problems located in the Guadalquivir Estuary (south-west Spain; see Section 1.2 for a description of the

Doñana region and Section 1.3 for the rationale of the research using that region as a case study). The sustainable use and management of wetlands and water resources is a widely acknowledged need (Davis and Froend 1999, Amezaga and Santamaría 2000, Zedler and Kercher 2005, MEA 2006). Indeed, water constitutes a strategic renewable resource subjected to increasing exploitation pressure, for which the need of new paths towards sustainable use has been urged (Gleick 2003, Folke 2003, Vadineanu and Preda 2008, Pahl-Wostl 2009). Wetlands, which strongly depend upon the water cycle, are most valuable due to their role as multi-scale, life-support systems contributing to maintain numerous ecosystem functions, goods and services to, inter alia, human beings (Costanza et al. 1989, RCS 2006, Martín-López et al. 2011). Essential services provided by wetlands include water storage, purification and supply; flood mitigation, erosion control and the stabilisation of local climate conditions (RCS 2006).

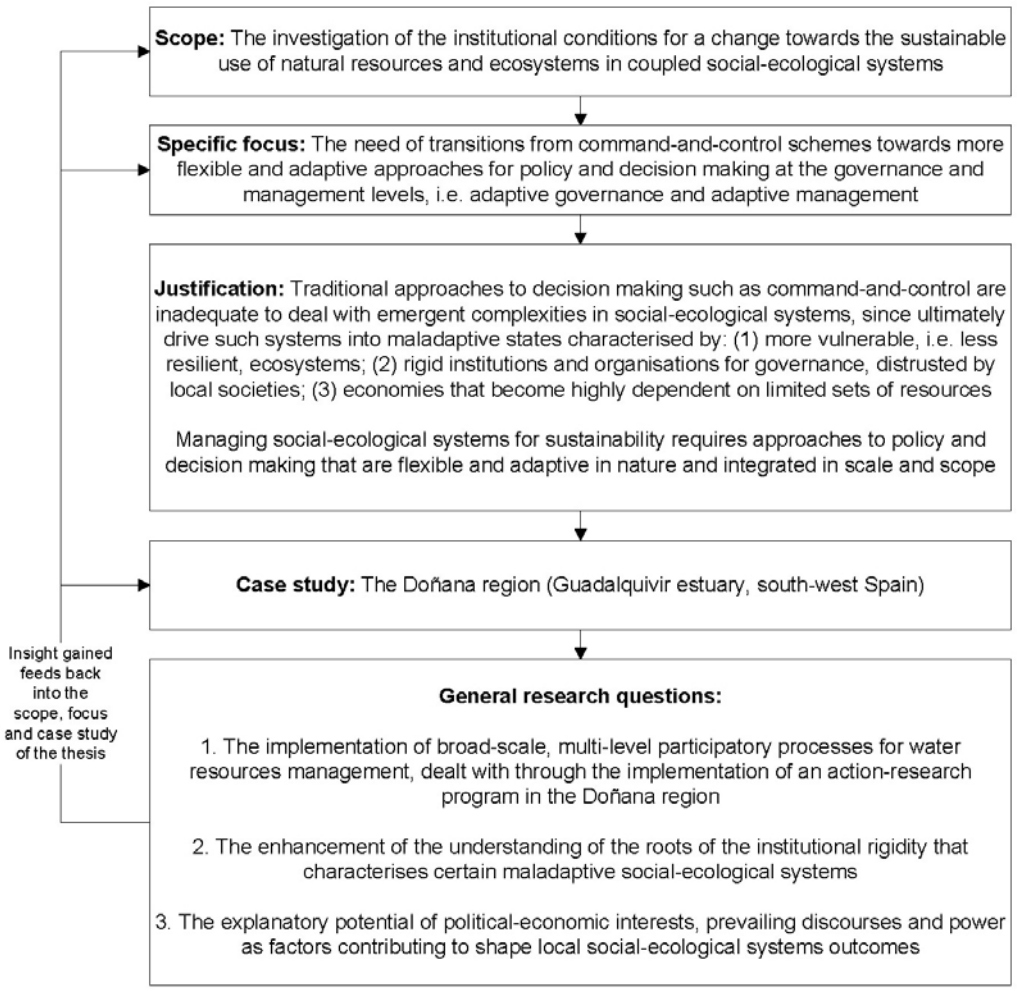

Figure 1. Logical relationship among the scope, specific focus, justification and general research questions of the thesis

Within the broad scope outlined above, my particular focus (Fig. 1) is on the need for transitions from command-and-control schemes towards more flexible and adaptive approaches for policy and decision making at the governance and management levels, i.e. adaptive governance and adaptive management. My focus is based on the following justification (Fig. 1). Managing social-ecological systems for sustainability requires the ability to cope with, adapt to, and shape change without losing options for future development (Folke et al. 2002). The uncertainty and complexity inherent to coupled social-ecological systems demand approaches to policy and decision making that are flexible and adaptive in nature and integrated in scale and scope (Gunderson and Light 2006, Pahl-Wostl 2007). However, current policies and management schemes are often based upon the recurrent application of linear approaches that obviate the complex, variable, and uncertain nature of resource systems and ecosystems (e.g., panaceas, blueprint solutions, cookbook approaches; Carpenter et al. 1999, Arrow et al. 2000, Scheffer et al. 2001, Brock and Carpenter 2007, Meinzen-Dick 2007, Ostrom et al. 2007, Olsson et al. 2008, Pahl-Wostl et al. 2012).

These approaches operate under two implicit assumptions: (1) a predictable biophysical world in static equilibrium; (2) productivity can be maximised infinitely through the simplification, centralisation and compartmentalisation of management operations, and the minimisation of the effects of natural variability (Costanza et al. 1993, Carpenter and Gunderson 2001, Folke et al. 2005, Ostrom 2009, Pahl-Wostl 2009). Operationally, these approaches are based on top-down, unique-target, command-and-control schemes whose main purpose is to avoid natural variability, reduce social and ecological uncertainties and maximise economic benefits through the exploitation of natural resources (Holling and Meffe 1996, Folke et al. 2005). However, changes in nature are not certain, gradual and linear, but complex, episodic and non-linear, making long-term predictions highly uncertain or untenable (Pahl-Wostl 1995, Holling and Sanderson 1996, Levin 1999). Uncertainties not only arise from the impact of man-made changes in future environmental conditions, but also from the inherent complexity of ecosystems, the uncertainty of users' responses to management decisions, the inaccuracies of management objectives, and the difficulties in assessing the abundance of the various resources being used (Johnson 1999). Moreover, human impacts on natural systems are manifest over different spatial and temporal scales, influencing numerous sectors of society (Cash 2000a, Cash 2000b).

The complexity of social-ecological systems "precludes a reductionist approach to management" (Ludwig et al. 1993). Traditional approaches to decision making such as command-and-control schemes are inadequate to deal with emergent complexities in natural resource and ecological systems and, by extension, in coupled social-ecological systems. Indeed, command-and-control schemes, although sometimes lead to short-term improvements, ultimately drive social-ecological systems into undesirable states (Olsson et al. 2006, Beier et al. 2009). Those states are largely maladaptive and characterised by the general features of the "pathology of natural resource management", namely: (1) more vulnerable, i.e. less resilient, ecosystems; (2) rigid institutions and organisations for governance, distrusted by local societies; (3) economies that become highly dependent on limited sets of resources (Holling and Meffe 1996). These characteristics diminish the capacity of social-ecological systems for coping with extreme, natural or human-induced external perturbations, hence compromising their long-term sustainability (Gunderson and Holling 2002).

During the process of change towards sustainability, more flexible and adaptive approaches ought to replace reactive command-and-control schemes that respond reactively, rather than proactively, to uncertainty and unpredictability. This replacement must take place at two levels: executive and management-technical. At the executive level, command-and-control schemes are replaced by adaptive governance, an emergent framework for the management of complex social-ecological systems aimed at integrating science, policy, and decision making (Folke et al. 2005; see also Brunner et al. 2006 and Brunner 2010 for similar approaches in other fields). This framework postulates the need for organising governance around systems of organizations, polycentric institutional arrangements, and networks of individuals with self-organisation and self-enforcing capabilities, in order to achieve an optimal balance between decentralised and centralised control (Folke et al. 2005). At the management and technical levels, sustainable approaches rely on the implementation of adaptive management, a critical component of adaptive governance characterised by three main features: (1) collaborative decision making, i.e. continual participatory processes aimed at defining problems and developing solutions collaboratively; (2) experimental approach, i.e. the acknowledgement and identification of uncertainties, and the understanding of management actions as alternative hypotheses to be tested through a structured process of investigation and experimentation to speed-up learning; (3)

learning from failure, i.e. policy or management failures are acknowledged as sources of learning (Holling 1978, Walters and Hilborn 1978, Walters 1986, Lee 1993, Lee 1999, Pahl-Wostl et al. 2005, Gregory et al. 2006, Polasky et al. 2011). Adaptive management aims to reduce our ignorance by using direct management actions as experiments to test implemented policies at the operational levels; adaptive governance deals with the institutional and organisational barriers and opportunities for the implementation of adaptive management (Gunderson and Light 2006). Indeed, adaptive governance is necessary because innovations like adaptive management often encounter institutional and organisational factors (e.g., rules, organisational structures, shared ideas and paradigms, individual attitudes) that may undermine successful implementation (see e.g., McLain and Lee 1996, Walters 1997, Gunderson 1999, Noble 2000, Alverts et al. 2001, Lee 2003, Stankey et al. 2005, Walkerden 2005, Marmorek et al. 2006, Folke et al. 2007, Méndez et al. 2010, Allen and Gunderson 2011, Greig et al. 2013).

Thus, an enhanced understanding of the current policy and institutional architecture in social-ecological systems would facilitate, in turn, an enhanced understanding of the effect of the mentioned architecture on the target transitional design needed for adaptive governance and management (Folke et al. 2007, Olsson et al. 2008). This task remains largely uncertain, due to the underdevelopment of this area of research, as well as to the dynamic and complex nature of social-ecological systems (Young et al. 2008, Young 2010, Österblom and Folke 2013). However, it is well established that distorted pictures of the dynamic and uncertain nature of complex social-ecological systems may lead to less effective or even counterproductive policy and institutional designs (Imperial 1999, Levin et al. 2013).

In this thesis, through the Doñana case study, I address three interrelated general questions of research interest (Fig. 1) for the scope and focus exposed above. The first one has implications for the implementation of participatory processes in the course of transitional design, while the other two have implications at a theoretic-analytical level.

The first research question of the thesis (Fig. 1) reflects a crucial challenge in the 'real world'. The implementation of broad-scale, multi-level participatory processes for water resources management is gaining momentum worldwide, promoting collective decision making and social learning towards the achievement of mutually acceptable water

policies (Daniell 2012). The key justification for participation is the inability of single governance structures to meet the required needs and goals through their assigned resources, especially in the case of decentralised governance regimes in which much power has been diverted to regional or local authorities and stakeholders (e.g., Western-style democracies; Daniell et al. 2010). These issues are being increasingly considered in specialised literature about adaptive approaches for the management of natural resources and ecosystems (Moellenkamp et al. 2010). In particular, the scientific community is increasingly aware of the incompleteness of existing knowledge, particularly when researchers are required to assist managers in making decisions and operations over the natural world. However, there are still broad institutional challenges and uncertainties that researchers, policy makers and managers have to confront in practice – in particular, about the degree of formality of the participation process (Priscoli 2004, Pahl-Wostl et al. 2007).

In the social-ecological field, it is suggested that informal schemes might be better for catalysing a process of change towards adaptive management (see e.g., Gunderson et al. 2006, Olsson et al. 2006). Contrary to formal processes, in which relationships among actors are shaped by legal regulatory structures, informal participation processes imply open rules for membership or negotiation, and voluntary agreements (Pahl-Wostl et al. 2007, Moellenkamp et al. 2010). By participating in the design and development of this type of processes, researchers are able to support change, while documenting and analysing the procedure and outcome (Pahl-Wostl 2006). This thesis uses a real-world implementation attempt in Doñana to assess the effectiveness of action research as a trigger of participatory processes allowing for informal collaborative learning and the development of policy guidance (Chapter 4). In particular, I assessed the usefulness of an action-research program for introducing adaptive management tenets at the Doñana's research-management interface (Fig. 1). The program was supported by preparatory research aimed at analysing the practices of and learning from best-in-class practitioners on adaptive management from British Columbia (Canada), where this approach was first conceived and implemented at large scale (see Chapter 3).

The second (theoretic-analytical) question of the thesis (Fig. 1) focuses on enhancing the understanding of the roots of the institutional rigidity that characterises certain maladaptive social-ecological systems. The constraints for adaptive governance and

adaptive management are particularly pronounced in maladaptive social-ecological systems in which recurrence in the application of command-and-control schemes has led to both high ecological vulnerability and institutional rigidity. In these social-ecological systems there is a general tendency (1) to hinder change, smother innovation and squeeze out diversity, and (2) to a mutual reinforcement of power, politics and profit (Holling et al. 2002, p. 96). Therefore, it is of utmost importance to understand and explain the origins of institutional rigidity, in order to facilitate potential transitions towards more sustainable social-ecological systems characterised by adaptive approaches to decision making (Herrfahrdt-Pähle and Pahl-Wostl 2012). Chapter 5 builds on the concept of institutional path dependence, to address the historical mechanisms underlying the genesis of rigidity in the Doñana region, which is affected by the recurrent application of command-and-control schemes.

The third (theoretic-analytical) question of the thesis (Fig. 1) is the explanatory potential of political-economic interests, prevailing discourses and power as factors contributing to shape local social-ecological systems outcomes (Holling et al. 2002, Armitage 2008, Voß and Bornemann 2011, Clement and Amezaga 2013). In Chapter 6, I discuss the explanatory potential of those factors, especially when the core logic of path dependence, composed by the mainstream principles of neoclassical economics, fail to predict observed outcomes in historical, evolutionary perspective. When this occurs, such outcomes are often qualified as unexpected due to their divergence from purported superior, optimal alternatives, hence subject to contingency. In particular, I make the case for the orderly inclusion of the mentioned factors (political-economic interests, prevailing discourses and power) into the analysis, so as to systematically inform premature qualifications of historical events or behaviours as proceeding by chance, as random, or, more generally, as contingent. Based on an epistemological paradox created by the notion of contingency, I shall argue that the very qualification of contingency can be modulated away from randomness and assessed as unpredictability through this type of systematisations. This would increase our capacity to predict the likelihood of certain types of outcomes in social-ecological systems. In turn, this would help in better informing future policy and institutional designs for successful transitions towards adaptive governance and management, hence improving the prospects for the sustainable use of natural resources and ecosystems.

I now turn to present the case study (Section 1.2) and the rationale for the research (Section 1.3). These two sections, in combination, describe and justify both how the research questions described above progressively emerged and the use of Doñana as case study. Finally, I present the main aim and objectives of the thesis (Section 1.4) and provide an overview of the ensuing chapters (Section 1.5).

1.2. Presenting the case study: the Doñana region

This thesis describes and presents the results of an 'action-research program' and 'institutional analysis' carried out in the Doñana region (Guadalquivir Estuary, south-west Spain; Fig. 2). The investigation is part of a broader long-term research program initiated at the Laboratory of Spatial Ecology of the Mediterranean Institute for Advanced Studies (IMEDEA, University of the Balearic Islands and Spanish Research Council) in the context of the lab's involvement in the hydro-ecological restoration project Doñana 2005 (see below). Located in the right bank of the Guadalquivir Estuary, the Doñana region is, to a large extent, the result of a complex history of tightly coupled relationships between humans, water resources and marshland/wetland ecosystems. At the core of the region, it can be found the remains of the largest wetland in the Iberian Peninsula and one of Europe's most emblematic conservation areas, protected within the Doñana Nature Reserve (Fig. 2).

During the last two centuries, the Guadalquivir's and Doñana's marshes and floodplain wetlands have been modified by the intensification of agriculture and water resources use, compounded in the last decades by accelerated tourism, infrastructure and urban development. As a result, they have lost most of their original extension and ecological complexity (Amezaga and Santamaría 2000, Fernández-Delgado 2006, García and Marín 2006). Such changes, along with other developments at the basin level (e.g., metalliferous mining, fluvial navigation), have bequeathed to the region increasing environmental hazards and nature conservation threats (e.g., over-extraction of groundwater, waterfowl mortalities, biological invasions), as well as intricate conflicts in the social realm (e.g., struggles with cattle and horse breeders, furtive hunting, economic dependence on external subsidies) (Amezaga and Santamaría 2000, González-Arteaga 2005, Fernández-Delgado 2006, Tablado et al. 2010, Martín-López et al. 2011, Palomo et al. 2011). In sum, while the core of the region enjoyed increasing

conservation since the 1960s, its surroundings have experienced fast socioeconomic development that has led to accelerated environmental degradation and conservation conflicts (Santamaría and Amezaga 1999, Amezaga and Santamaría 2000, Fernández-Delgado 2006).

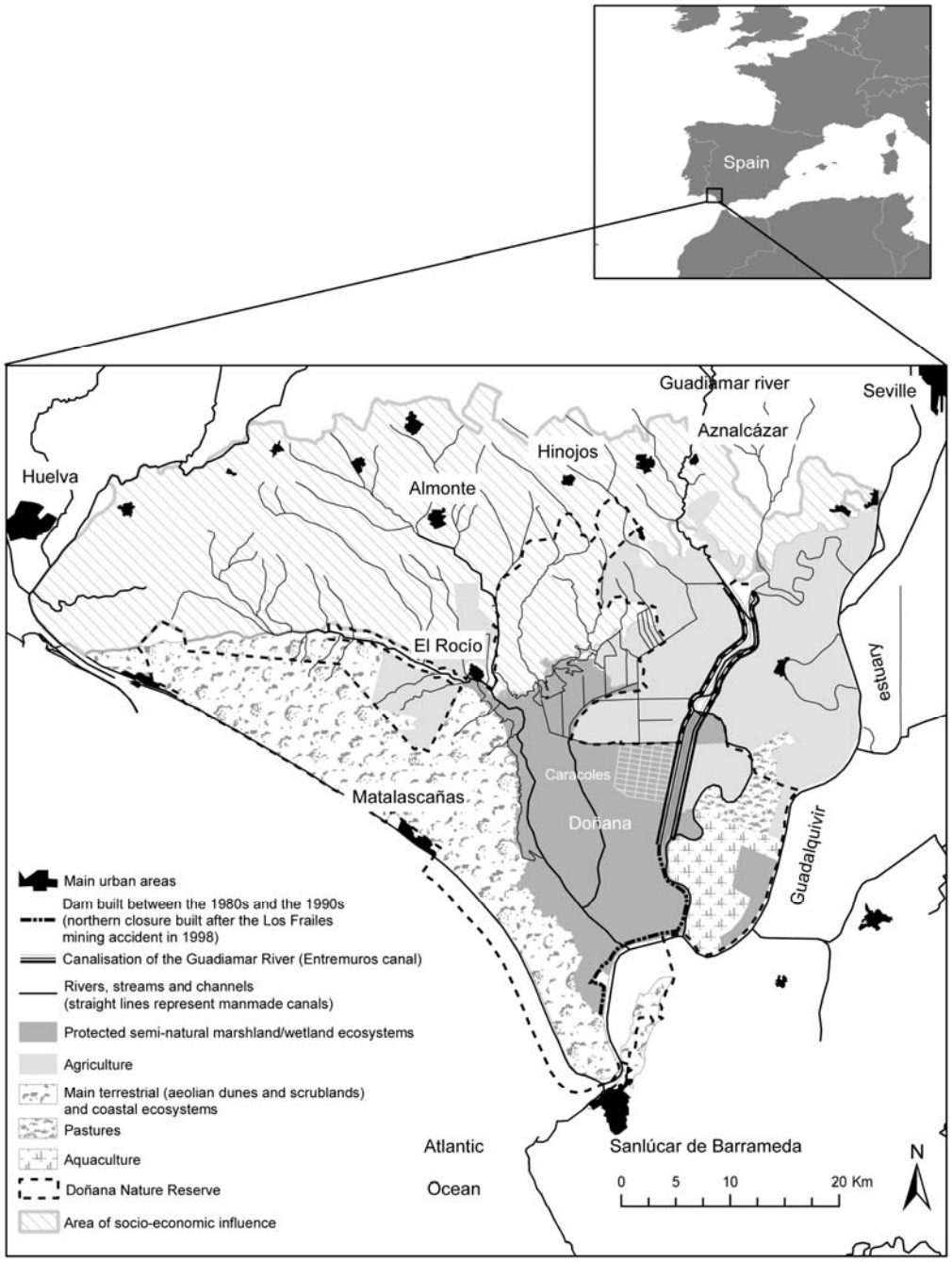

Figure 2. Geographical location of the Doñana region

Source: own elaboration from POTAD (2003)

All these conflicts between development and conservation have tipped in multiple occasions, causing repeated environmental and ecological crises. The most important were probably the massive mortalities of waterfowl in 1973 and 1986 (Castroviejo 1993) and, more recently, the toxic spill at Los Frailes zinc mines, located in Aznalcóllar (Seville, Spain). In April 25 1998, the accidental collapse of the tailings dam of those mines released more than 5 million m^3 of waste to the rivers Agrio and Guadiamar (see Aparicio et al. 1998, Meharg et al. 1999, Taggart et al. 2004). The spill reached the north-eastern inflow to the marshlands/wetlands of the Doñana Nature Reserve (Entremuros canal; Fig. 2). The spill did not enter the protected marshland/wetlands, owing to a coordinated action of the management authorities, but an estimated 4 Hm^3 of the polluted mud containing heavy metals and acidic water were directly discharged into the Guadalquivir River (Grimalt et al. 1999). The clean-up of the rest of the toxic sludge, along the 40 km stretch affected by the spill, provided the impetus for the development of two hydro-ecological restoration projects: the Guadiamar's Green Corridor (1998-2002, see e.g., Montes 2002, Arenas et al. 2003), coordinated by the regional authorities outside the Doñana Nature Reserve, and Doñana 2005 (1998-2006, see e.g., García and Marín 2006), coordinated by the national authorities within the Reserve.

The research presented in this thesis paralleled the implementation of the Doñana 2005 project, aimed at restoring the hydraulic and ecological functioning of the protected marshland and wetlands, which got further deteriorated after the Los Frailes spill. The project made an explicit notice to the need for establishing "new alliances between science and management" (García and Marín 2006, p. 305). Several actors recognised the project as a unique opportunity to introduce new modes of management and succeeded to start a pilot initiative based on adaptive management tenets (Santamaría et al. 2006). This initiative aimed at restoring an expropriated plot of marshland that had been transformed into farmland in the 1960s ("Caracoles" estate, 2600 ha; Fig. 2). The adaptive management initiative at Caracoles was based on the recommendations of an external advisory panel of experts prior to the implementation of the restoration (Meffe et al. 2002, *unpublished report*). The initial design included a short intensive action, coupled with a long-term monitoring plan, which aimed at implementing an alternative solution with the specific goals of ensuring long-term success, fixing adequate baselines (in time and space) as references, and focusing in patterns (e.g., biodiversity) and

functions (e.g., productivity). The consulted panel of experts prescribed adaptive management as an alternative to the more classical approaches traditionally chosen on the ground. Their main aim was to overcome the main challenges, both ecological and institutional, that initially faced the Caracoles estate restoration project, which were not collectively posed upfront. Another goal was to avoid putatively-optimal solutions to ecological restoration (e.g., the identification of an optimal flooding cycle), and provide a strategy for sustained learning about the factors that enhance ecosystem resilience to variation in flooding cycles (e.g., diversification of the marsh spatial structure and wetland connectivity). Finally, a longer-term goal was to extend the knowledge generated through the management of the restored area to the management of the whole marshland/wetland area.

1.3. Rationale of the research

Both restoration projects, Guadiamar's Green Corridor and Doñana 2005, offered numerous opportunities for the promotion of new institutional configurations. In particular, there was enough flexibility for enrolling a wide range of stakeholders and developing new forms of participation and management at the operational levels (e.g., participatory action research, Escalera 2003; adaptive management, Santamaría et al. 2006). However, the inertia of traditional command-and-control and civil-engineering-based schemes progressively compromised these initiatives. Thus, after a period of creativity largely restricted to the declarative phase, both hydro-ecological projects returned to top-down models of organisation and implementation based on the endorsement of civil engineering works. Proof of this can be seen in the post-implementation reports by Arenas (2003) or Arenas and Carrascal (2004), in which references to adaptive and participatory approaches are conspicuously absent, or in the specific restoration works reported in García and Marín (2006). In particular, the adaptive management initiative in Caracoles faced several challenges at the institutional (i.e. policy and decision making) arena, namely that:

- Due to historical inertia, the management institutions in place appeared to be fearful of innovation in management planning and operational design.

- Local academics distrusted the new approach – in particular the need to establish an explicit link between research and management. In doing so, they broadened the dissociation between both sectors.

The initial aim of this thesis was the identification of institutional opportunities and constraints for developing a full cycle of adaptive management in the Caracoles restoration, in particular, and in the Doñana Nature Reserve, in general. More specifically, through an institutional analysis based on document reviews, interviews and workshops, the aim was to evaluate whether adaptive management: (1) could be used at the operational levels of the Reserve, in particular, at the research-management interface; (2) represents a significant avenue for the resolution of the long-standing conflict between water resources management and wetland conservation in the region. Based on these objectives, I established the 'Doñana Nature Reserve' as the 'case study', and its 'institutional framework' for water resources management and wetland conservation as the 'unit of analysis', at the outset of the research.

However, there were two main developments in the research design that broadened the initial aim of the thesis, as well as the extent of the planned institutional analysis, interviews and workshops (see Fig. 3 for a graphical depiction). The detailed description of these developments is important, since they: (1) provide the rationale for the three interrelated research questions exposed in Section 1.1 as related to the scope and focus of the thesis; (2) marked an inflection point between an exploratory and a confirmatory phase in the research; (3) are of methodological relevance for debates on qualitative research designs. It is important to emphasise that these developments were possible due to the decision to establish a 'flexible research design' for the thesis. Flexible research designs allow for the specification of research components along the course of the study. The methodology of inquiry evolves incrementally in response to new insights that are, in turn, generated through a process whereby ideas, design, data collection and analysis, and writing tasks proceed in an iterative manner, rather than in separate stages (Robson 2002). Flexible designs enable "to capitalise on unexpected eventualities" along the enquiry (Robson 2002, p. 6), such as these presented here.

The first development in the research design (Fig. 3) corresponds with the first research question of the thesis (see Section 1.1). In particular, this development consisted in the

decision to explore the instrumentality of action research as a proactive, informal and participatory bottom-up means for introducing adaptive management tenets at the research-management interface of the broader Doñana region as part of the Guadalquivir Estuary – thus broadening the initial focus on the Doñana Nature Reserve (Fig. 3). More specifically, through the actual implementation of an action-research program, described in higher detail in Chapter 4, the planned interviews and participatory workshops were used to build trust among stakeholders, to facilitate their involvement in such program, and to produce policy guidance on the improvement of the research-management interface. The research was specifically tailored to meet the requirements of the approach to adaptive management implemented in Caracoles, which used an experimental design and monitoring aimed at speed-up the learning process (Santamaría et al. 2006)[1]. However, the program was used to propose improvements in water resources management and wetland conservation at a broader geographical, policy and institutional level within the Guadalquivir Estuary. This was realised through the involvement of stakeholders from a wide range of institutional and organisational levels, and by broadening the scale and scope of the discussions at the final workshop of the program. The main criteria to use action research were its usefulness for involving stakeholders in a project in which they were, at the same time, the focus of the research (see Chapter 2, Section 2.2.2). The formalised documentation of the program was used to assess its effectiveness for this purpose and to learn from it along the way, thus applying to it the very learning-by-doing tenets of adaptive management. This research stage was also supported through an investigation on best-practices in adaptive management at British Columbia (Canada) (see Chapter 3). Finally, the development of the program was influenced by a working hypothesis (H_1; see Box 1). Such hypothesis was not aimed at thorough evaluation in the timeframe of this thesis; instead, H_1 was established for guidance purposes.

[1] That approach contrasts with other initiatives implemented in the hydro-ecological restoration projects Doñana 2005 and Guadiamar's Green Corridor. Those initiatives made explicit the use of adaptive management as a means to reduce uncertainties, but focused on learning and monitoring more as trial-an-error and adapt-as-you-go processes (see e.g., García and Marín 2006, p. 273, Montes 2002, Montes and Carrascal 2008, p. 224). It is important to make explicit the assumptions underlying the learning process, in order to prevent misleading extrapolations of the lessons learnt in this research to other applications of adaptive management in Doñana.

Box 1. Working hypothesis (H_1) guiding the action-research program.

H_1: The development of 'action-research programs' is instrumental for implementing 'adaptive management' at the 'operational levels' in 'maladaptive water socio-ecosystems', thus facilitating the long-term transition from 'rigid' to more 'flexible and adaptive institutional regimes' for 'water resources management' and 'wetland conservation'

The second development in the research design corresponds with the second research question of the thesis, which is of theoretic-analytical nature (see Section 1.1). That question progressively emerged from the previous action-research program (Fig. 3). In particular, a historical institutional assessment performed to inform such program (see Chapter 4, Section 4.3.1), together with in-situ observations during the program, revealed a rich historical record of application of command-and-control schemes in both the water resources management and the wetland conservation functions in the Doñana region (Fig. 3). This realisation, complemented by comparisons with other social-ecological systems (Gunderson et al. 1995, Holling and Meffe 1996, Gunderson and Holling 2002, Allison and Hobbs 2004), led me to the conception of the Doñana region as a case study of 'maladaptive social-ecological system' characterised by the key features of the "pathology of natural resource management", as have been defined in Section 1.1 (see also Fig. 3), namely: (1) a highly vulnerable (i.e. low resilient) marshland/wetland ecosystem; (2) institutional rigidity in the water resources management and wetland conservation functions; (3) an origin in the recurrent application of top-down, command-and-control schemes (see also Gómez-Baggethun and Kelemen 2008). As has been argued in Section 1.1, in general, the recurrence in the application of command-and-control schemes and institutional rigidity in maladaptive social-ecological systems combine to hinder change and innovation, and favour the mutual reinforcement of power, politics and profit. Therefore, I turned to an in-depth institutional analysis of the current configuration and historical origins of institutional rigidity as a core feature of the maladaptive state of the Doñana region (see Chapter 5). As I shall show throughout the thesis, this development gave rise to the second theoretic-analytical research question of the thesis (Fig. 3), which is dealt with in Chapter 6.

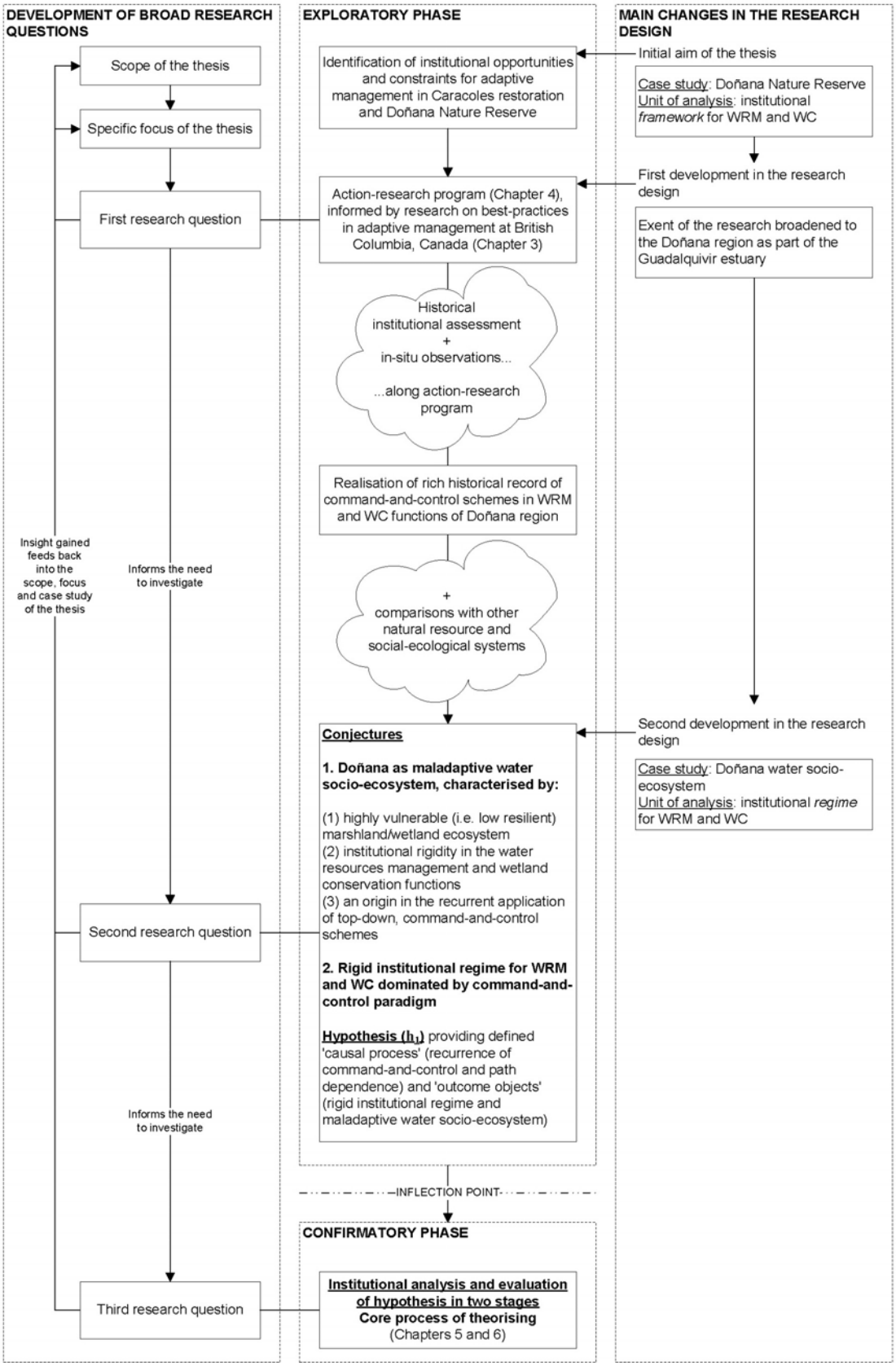

Figure 3. Graphical depiction of the rationale of the research, showing the two main developments in the research design

WRM = water resources management, WC = wetland conservation

To inform the institutional analysis presented in Chapters 5 and 6, I elaborated a theoretical framework relying on a diverse array of theories (Chapter 2, Section 2.3). From that framework, it is necessary to highlight here the following two issues to further facilitate the understanding of the rationale of the research. First, based on the concept of institutional path dependence (see Chapter 2, Section 2.3.3), I elaborated a hypothesis (h_1) about the origins of the institutional rigidity and the maladaptive state of the Doñana region (see Box 2)[2], which I thoroughly evaluate in the institutional analysis. Second, as can be seen, hypothesis h_1 focus on the concepts of 'rigid institutional regime' and of the Doñana region as a 'water socio-ecosystem'.

Box 2. Specific deduced hypothesis (h_1) addressing the causality of the Doñana's rigid institutional regime and maladaptive stable state.

h_1: The historical recurrence of 'command-and-control schemes' is a 'path-dependent process' that has led to the emergence of a 'rigid institutional regime' for water resources management and wetland conservation in the 'Doñana water socio-ecosystem', and caused it to enter and get trapped in a 'maladaptive stable state'.

The concept of 'regime' was introduced in this research for the analysis of institutional rigidity replacing that of 'framework' (initially used to define the unit of analysis; see above), for the following reason. Unlike the concept of 'framework', which focused just upon institutions, the concept of 'regime' was used due to my growing interest in analysing, in an integrated way, three important components of the socio-institutional system that the mentioned 'regime' concept amalgamates, namely: 'organisations' (e.g., management and research agencies) besides 'institutions' (e.g., regulations, procedures), and the 'epistemological paradigm' underlying both of them. This interest materialised first in the elaboration of a general propositional conceptualisation of 'institutional regimes', which integrate those three components; and, subsequently, in a particular conceptualisation of 'rigid institutional regimes' as a specific type of regime dominated by a command-and-control paradigm (see Chapter 2, Section 2.3.1 for a detailed articulation and justification). The conceptualisation of the broader Doñana region as a 'water socio-ecosystem' was specifically tailored for the institutional analysis of the thesis presented in Chapters 5 and 6 (see Chapter 5, Section 5.2.1 for a detailed articulation and justification). Thus, the insights gained through the action research

[2] It is to be noted that the wording of hypothesis h_1 has been adjusted to the terminology used in the thesis, but its core meaning remains intact with respect to its published version in Méndez et al. (2012).

program resulted, in Chapters 5 and 6, in a shift to the 'Doñana water socio-ecosystem' as the 'case study'; and to its 'institutional regime for water resources management and wetland conservation' as the 'unit of analysis' (for details on the case study design as a method see Chapter 2, Section 2.2.1).

The hypothesis h_1 gave direction to the institutional analysis by providing a defined 'causal process' (i.e. recurrence of command-and-control and path dependence) and 'outcome objects' (i.e. rigid institutional regime as the pivotal feature of the Doñana maladaptive water socio-ecosystem) to search for along such analysis (Fig. 3). Nevertheless, while proof on the recurrence of command-and-control schemes seemed to be strong, proof of the existence of a rigid institutional regime in Doñana was still deemed as weak. Therefore, the two propositions of Doñana as a maladaptive water socio-ecosystem and of the existence of a rigid institutional regime at the pivotal feature of the former were initially established as conjectures (Fig. 3). As such, they allowed proceeding to the institutional analysis and to the evaluation of hypothesis h_1, while concurrently searching for further proof of their existence. As it will be shown, the institutional analysis and the evaluation of hypothesis h_1 performed in Chapters 5 and 6 consisted in two main stages having as common denominator a core process of theorising that constituted the confirmatory phase of the research. See Figure 3 for the logical connection between the exploratory and the confirmatory phases; Chapter 2, Section 2.3.2, for a more detailed description of the core process of theorising.

1.4. *Grand tour* question, main aim and specific objectives

The establishment of *grand tour* questions aims to avoid a priori restrictions to the research, allowing it to explore problems with wider latitude. This type of questions is consistent with the methodology of the research, but "is posed as a general issue so as not to limit the inquiry" (Creswell 1994, p. 79). This thesis aims at answering a *grand tour* question fully defined after the exploratory phase of the research. Its establishment was guided by the broad research questions described in Section 1.1 and by the conjectures and hypothesis of the thesis established in the prior section.

In the question, aim and objectives of the thesis, and until Chapter 5, I will refer to the case study as the 'Doñana region'; and from Chapter 5 onwards, I will refer to the case

study as the more specific 'Doñana water socio-ecosystem' – both contextualised as part of the Guadalquivir Estuary.

The grand tour question of the thesis is:

What are the main institutional opportunities and constraints for the development of more flexible and adaptive approaches for water resources management and wetland conservation in the Doñana region?

This grand tour question drove the establishment of the main aim and specific objectives of the thesis as follows. The aim of the thesis is:

To understand and explain the main institutional opportunities and constraints for the implementation of adaptive governance and management in the Doñana region, with a specific focus on (1) its institutional regime for water resources management and wetland conservation, and (2) the research-management interface.

To address this aim, I established the following five specific objectives:

1. To learn from best-in-class practitioners on adaptive management from British Columbia (Canada), in order to support the implementation of the action-research program described in the next objective.
2. To explore the instrumentality of action research for facilitating stakeholder involvement in current and future implementations of adaptive management in the Doñana region, with a particular focus on the research-management interface.
3. To understand and explain the historical genesis (origin, operation and evolution) of the institutional regime for water resources management and wetland conservation of the Doñana region, assessing, in particular, the causal weight of history in the regime's current rigid configuration.
4. To understand and explain the mechanisms stabilising the regime around its current rigid configuration.
5. To develop policy guidance and recommendations for future implementations of more flexible, participatory and adaptive approaches for water resources

management and wetland conservation at the governance and management levels in the Doñana region, based on the results of the research.

Objectives 1 and 2 correspond with the exploratory phase of the research. Objectives 3 and 4 correspond with the institutional analyses (confirmatory phase). All these objectives were operationalised at each research stage, in order to align them with the methods-in-use. At this point, it is worth making explicit that the thesis has a 'normative component' ('how things should work') that must be differentiated from the 'research component', which is aimed at understanding and explaining real-world phenomena through research ('how things work'). In particular, this serves to explicitly declare that: (1) the research, which is derived as a last step of the thesis, aims at informing the normative component; (2) the thesis has a subjective component, in that the research is defending a policy and institutional choice (i.e. the adaptive paradigm, as opposed to alternative options, such as command-and-control schemes); (3) the research is, with more or less success, proactively transferring the mentioned paradigm to a policy-institutional realm, through an action-research program. Indeed, at a normative level, this thesis aims to inform the existing debate about potential policies and institutional designs for a process of change towards a sustainable Doñana, based on more flexible and adaptive approaches for governance and management (see e.g., Palomo et al. 2011).

1.5. Overview of the thesis

The research described in this thesis consists of five research stages that are described in Chapters 2, 3, 4, 5 and 6 (see Fig. 4 for an overview of the structure of the thesis). Chapter 2 describes the methodology employed in this thesis. The four chapters following the methodology conform the core research stages of the thesis.

Chapter 3 describes the research carried out in British Columbia aimed at learning about the Canadian experience on adaptive management (specific objective 1). The lessons learnt in that research served to support the action-research program developed in the Doñana region. This action-research program is then described in Chapter 4 (specific objective 2). The program paralleled a large-scale restoration program at Caracoles estate that adhered explicitly to the tenets of adaptive management. This program was informed by a historical institutional assessment of the Doñana region.

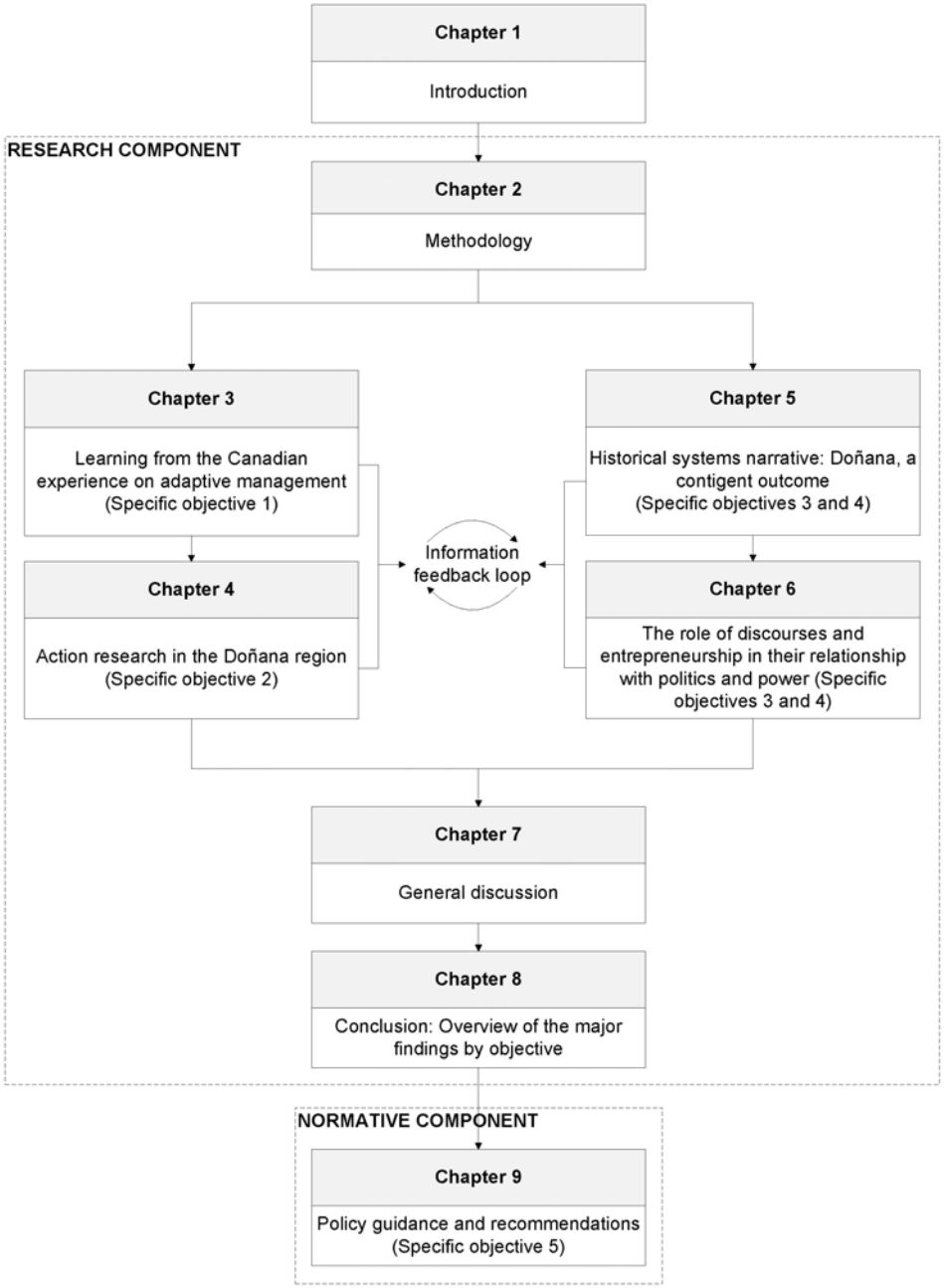

Figure 4. Flow diagram of the thesis

In Chapter 5, building on that preliminary assessment, I present a deeper historical analysis that delves into the origins and development of the conjectured Doñana's rigid institutional regime for water resources management and wetland conservation (specific objectives 3 and 4). By informing analysis through institutional and resilience theories, I conclude that the regime has been subjected to institutional path dependence and that the whole Doñana water socio-ecosystem is currently stabilised in a rigidity trap, an outcome that I qualify as contingent. In Chapter 6, based on a paradox inherent to the

concept of path dependence and contingency, I challenge the outcome of the prior analysis in a deeper study about the role of discourses and entrepreneurship in their relationship with politics and power, in the formation of such outcome (specific objectives 3 and 4).

Each of these four chapters ends with a concluding section that recapitulates the major findings of the research. Then, Chapter 7 includes a general discussion of these findings, an evaluation of the implications of the research within a European institutional context, an evaluation of the main methodological limitations of the research and a section on lessons learnt and directions of further research. The thesis concludes with an overview of the major findings of the thesis by objective (Chapter 8) and a series of policy recommendations for a transition towards adaptive governance and management in the Doñana region (specific objective 5; Chapter 9).

Chapter 2. Methodology

2.1. Introduction

Except for the action research method and the methods used in the research carried out in British Columbia, the methodological elements included here were established after the exploratory period of the thesis. Methodology is understood in this thesis as a strategic guideline both organising and enabling the examination of the rationale that underlies the following core components of the research: the general methods; the theoretical framework; the theories and concepts that such framework conveys; the definition of the case study and unit of analysis; the mode of thinking and inference procedures at work; and the specific methods used for data collection, analysis and interpretation (based on Grix 2002). The design of my research and the establishment of its methodology rely on three principles. First, a continuous effort for 'being scientific', i.e. to work under the principles of the scientific method. According to Robson (2002), research designs relying heavily on social research methods must consider the following questions: Can the research be scientific? What does this mean? Do I, as a researcher, want to be scientific? These questions were critical for this research, which aimed at approximating the 'truth' about the researched objects through the development of a rigorous research design based on scientific principles. My research was thus committed to what Robson (2002) calls 'principled enquiry', i.e. the arguments behind the intentions to 'be scientific', to retain and explicitly declare a scientific approach to research, and to clarify the advantages of doing it. For this purpose, I adopted what Robson calls a "scientific attitude", in which "the research is carried out systematically, sceptically and ethically" (Robson 2002, p. 18). Second, this principle was further elaborated through a set of specific criteria to ensure trustworthiness in the research (based on Robson 2002, Hsieh and Shannon 2005, Yin 2009), namely:

1. A continuous interaction with the consulted research literature about the diverse theoretical subjects incorporated in the theoretical framework and about the case

study, in order to minimise personal biases, and to develop a sustained awareness about the identity and influence of personal values (vs. value-removal).

2. The clear, complete and truthful reporting of: (1) methodological devices such as the theoretical framework or the inference procedure, so as to pave the way for testability, replicability and future applications; (2) theoretical propositions, conceptual elements and assumptions, so as to make them liable to empirical refutation (i.e. falsifiability); (3) results in sufficient detail, so as to allow for the inter-subjective evaluation of validity and verifiability.
3. The provision of my account of results with a due balance between description (i.e. background and context) and analysis and interpretation (i.e. understanding of the phenomenon under study, in the light of findings and the posited theoretical propositions). I attached explanations to every observation, as well as available evidence in support of such explanations. This sought to provide my accounts with credibility, as well as providing readers with enough fundament to look for alternative interpretations.
4. Persistent and systematic observation during the action-research program.
5. A commitment to high-standard work, so to reach an ideal level of objectivism, while acknowledging the difficulty of generating a totally neutral explication of the social-institutional reality under investigation. The crafting of detailed accounts of my results was not intended to be an absolute and final representation, but a plausible and credible account, liable to inter-subjective evaluation and to be proved wrong.

Finally, the present research adopts a qualitative design. Qualitative research focuses on verbal descriptions and explanations of human behaviour, by means of tools such as participant observation, interviews, or case studies (Robson 2002, Mills et al. 2010, Trochim and Donnelly 2007, Hammersley 2013). Quantitative research, in contrast, seeks to convert observations to numbers, test hypotheses on the basis of samples of observations, and statistical analyses of the data or mathematical descriptions of relationships among variables (Robson 2002, Mills et al. 2010, Hammersley 2013). I chose a qualitative approach for two main reasons. On the one hand, because qualitative evidence was the best approach to start exploring the Doñana's institutional realms and to build trust with and catalyse the participation of actors in the action-research program. Through the collection and analysis of qualitative information, both from

document reviews and interviews, I expected to gain a thorough understanding of and to refine the questions at hand, before embarking on deeper institutional analyses. Additionally, through the use of open-ended interviews, I expected to gain a deep understanding about how the interviewed actors were making sense of the challenges that I was raising, as well as about how they were experiencing them in their day-to-day work. Indeed, this type of approach allows the researcher to empathise with how the actors make "sense of their world and the experiences they have in the world" (Merriam 2009, p. 13). By interacting with actors in this way, I sought to build trust on both the research team and the action-research program, hence to increase the likelihood of participation in the latter. On the other hand, as I shall show, the institutional analysis presented in Chapters 5 and 6 aimed at searching causal 'mechanisms' (see Section 2.4) whose proof and understanding is better attained through a qualitative approach (e.g., recurrence of command-and-control schemes, institutional reproduction, power and discursive phenomena). Nevertheless, my institutional analysis, which is based on a qualitative narrative approach using historical evidence, is, at several points, backed by quantitative evidence. Moreover, my analysis does not preclude the use of deeper quantitative studies in the future. In fact, institutional analysis based on narratives using historical evidence endorses the use of quantitative methods (Alston 2008).

I now turn to a description of the elements composing the methodology, starting by the general methods of the research. I first describe the single-case study design due to its transverse character. Then I define action research as applied in this thesis. Afterwards I tackle the description of the theoretical framework. I do this in rich detail and anticipating certain results of the thesis, in order to facilitate the reading of the chapters including the four research stages of the thesis, in particular, the institutional analysis included in Chapters 5 and 6. Finally, I describe the main mode of thinking and inference procedure employed for the elaboration of hypothesis h_1, as well as along the institutional analysis and its core process of theorising. The methods for data collection, analysis and interpretation used at each of the four research stages are very specific, so they are described in greater detail in their respective chapters, especially the construction of the historical systems narrative (Chapter 5) and explanation building (Chapter 6).

2.2. General methods

2.2.1. Single-case study design

The case study method, as approached by Yin (2009), is the core method of this thesis. There are three main conditions that, according to Yin (2009), serve as general criteria for selecting among five of the major existing methods in social research (experiments, surveys, archival analyses, histories and case studies). Such conditions are: (a) the type of research question(s) posed, (b) the extent of control an investigator has over actual behavioural events, and (c) the degree of focus on contemporary as opposed to historical events (Yin 2009, p. 8). The importance of each condition allows making an informed decision about what method best suits the research needs. This research departs from a 'what' grand tour question, but its answer requires the investigation of the 'how's' and 'why's' of the Doñana's rigid institutional regime and maladaptive state, i.e. some form of explanatory (vs. descriptive) answer. Also, the research didn't require the control of behavioural events and, although requiring historical analyses, it focuses on contemporary phenomena. Based on this assessment, the case study method was selected as the backbone of the methodology of this research. In particular, a single-case study design best served the purposes of the research on the basis of the following specific criteria:

1. The need for retaining the holistic and meaningful characteristics of the real-life events under analysis (Yin 2009, p. 4).
2. The need to analyse such events at different spatiotemporal scales in a "longitudinal" fashion (Yin 2009, p. 49).
3. The character of the case as "critical" for testing theory from different perspectives, i.e. rival theories (see the core process of theorising below in Section 2.3.2), and potentially "representative" for other similar cases (Yin 2009, pp. 47-48).
4. The specificity of the single-case study design for accomplishing the normative component of the thesis (Yin 2009, p. 49, Box 9).

I then used the set of criteria proposed by Yin (2009) to address the logic of design of the case study. This logic consists of the twofold set of technical definitions included in Table 1, to which I enclosed the rationale for its application to the Doñana region.

Table 1. The logic of design of a case study and the rationale for its application to Doñana

Logic of design	Rationale
1. A case study is an empirical inquiry that	
a. investigates a contemporary phenomenon in depth and within its real-life context	The understanding and explanation of a contemporary phenomena ('rigid institutional regime', 'Doñana's maladaptive state') through the examination and analysis of historical and current evidence
b. especially when the boundaries between phenomenon and context are not clearly evident	The research design has invariably corresponded with an embedded design (Yin 2009, p. 50), but boundaries between context and phenomenon, which are defined by the unit of analysis at every research stage, were not clearly evident at the outset of research. The context and unit of analysis have therefore changed along the research
2. The case study inquiry	
a. copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result	The composite of patterns and causal links that compose the theoretical framework were very complex and difficult to measure precisely
b. relies on multiple sources of evidence with data needing to converge in a triangulating fashion	The research relies on multiple sources of evidence and strived for data triangulation
c. as another result, benefits from the prior development of theoretical propositions to guide data collection and analysis	The development of the theoretical framework was performed thoroughly and sequentially and guided data collection and analysis

Source: adapted from Yin (2009, p. 18)

As a general design my research uses an embedded design (see Fig. 5), deemed appropriate owing to its capacity and flexibility for defining and accommodating shifts in definition of both the case and the unit of analysis (as those described in Chapter 1, Section 1.3). These shifts in definitions are described in figures in their respective chapters, depicting how the embedded design accounted for them.

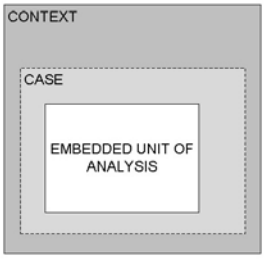

Figure 5. The embedded design for case studies

Source: adapted from Yin (2009, p. 46)

The case study method acts as a 'container' framing the rest of the methods used in the thesis, in coherence with a pluralistic approach to research. In taking this measure, this thesis departs explicitly from the "hierarchical stereotype" of methods (Yin 2009):

> *"A common misconception is that the various research methods should be arrayed hierarchically. Many social scientists still deeply believe that case studies are only appropriate for the exploratory phase of an investigation, that surveys and histories are appropriate for the descriptive phase, and that experiments are the only way of doing explanatory causal inquiries. This hierarchical view reinforces the idea that case studies are only a preliminary research method and cannot be used to describe or test propositions."* (Yin 2009, p. 6).

In terms of 'generalisation of results', the present investigation can move from the specific to the general. However, due the single-case study design, the results of the research cannot be generalised to "populations or universes" (i.e. statistical generalisation) but to theory (i.e. analytical generalization) (Yin 2009, p. 15). Theory is used as a template with which to compare the empirical results of the case study.

2.2.2. Action research

To differentiate 'action research' from the 'case study' method is important in studies focused on complex social-ecological systems and aimed at understanding real-world social situations from an observational perspective (Rogers et al. 2013). Action research is not a matter of vertical knowledge transfer from researchers, but a mutual engagement approach based on the collaboration of the researchers and those actors who are the focus of the research (Susman and Evered 1978, Robson 2002). It is adequate for solving intricate, complex social problems through the collaborative understanding of both their underlying causes and the changes needed to realise such solutions (Robson 2002). Indeed, the main aim is to define a desired future situation, as well as a strategy towards that situation, which might involve changes at multiple levels (e.g., individual, organisational, institutional) and the development of deep trust among parties as an indispensable prerequisite for success (Rogers et al. 2013). One of the more important challenges that might hinder the emergence of trust is the lack of a

"common frame of reference for decision making and 'walking-the-talk'" along the path that takes researchers, users and stakeholders forward (Rogers et al. 2013).

This thesis explores the instrumentality of action research for the proactive introduction of adaptive management tenets at the research-management interface (Chapter 4). In particular, it was assessed its effectiveness as a broad, informal and participatory bottom-up means for introducing adaptive management tenets. Specifically, through an array of carefully selected methods from social research and Systems Dynamics, action research was used to build trust among stakeholders, to facilitate their involvement in the program, and to produce policy guidance on: (1) the improvement of the research-management interface in the Doñana region; (2) the introduction of innovations such as adaptive management; (3) water resources management and wetland conservation at a broader geographical, policy and institutional level (see Chapter 4). As mentioned above, the program was supported by research aimed at learning from 'best-in-class' adaptive management practitioners from British Columbia (Canada) (see Chapter 3).

2.3. Theoretical framework

This section describes the elements of the theoretical framework of the thesis, based on the next two arguments, which have already been posed in Chapter 1, Section 1.3. On one side, the institutional analysis presented in this thesis is directed by a specific hypothesis about the origins of the institutional rigidity and the maladaptive state of the Doñana region. On the other side, the institutional analysis was performed in two main stages that had as common denominator a core process of theorising included in Chapters 5 and 6. Given the centrality of the concept of 'rigid institutional regime' in the hypothesis, in particular, and in this research, in general, I first define that concept in next section. It is worth noting before that this research, although working in the abstract at some points of the process of theorising, is not meant to undertake a highly theoretical abstraction nor seeks a grand-theory. Thus, the elaboration of the theoretical framework involved the minimisation of the number of theoretical and conceptual elements needed to provide valid explanations and to challenge assumptions. It also involved an effort to articulate these elements at middle-range, making them suitable for a progressive empirical investigation that yields robust results and warrants future developments and practical applications (sensu Merton 1968, p. 39).

2.3.1. Rigid institutional regimes

As mentioned in Chapter 1, Section 1.3, the exploratory phase of the research led to conjecture the Doñana region as governed by a 'rigid institutional regime' for water resources management and wetland conservation, which have led the region towards a 'maladaptive' state. To evaluate the existence of the rigid institutional regime I developed a deductive, formal and testable propositional conceptualisation of both 'institutional regimes' and 'rigid institutional regimes'. Their original conceptualisations are included in Méndez et al. (2012). Both were developed on the basis of pre-existing approaches and concepts from the literature (Gunderson et al. 1995, Holling and Meffe 1996, Ostrom 2005, Hotimsky et al. 2006, Pahl-Wostl 2007, Fischer-Kowalski and Rotmans 2009). In this thesis, they have been refined preserving their original meaning, as follows:

An institutional regime is a specific configuration of institutions, organisations and epistemological paradigms that fulfil a certain societal function, at a certain spatiotemporal scale.

A rigid institutional regime operates under a command-and-control epistemological paradigm.

The main features defining a command-and-control paradigm as the fundamental property of rigid institutional regimes were also established on the basis of pre-existing concepts from the literature (see e.g., "prediction and control regime"; Moberg and Galaz 2005, Pahl-Wostl 2007):

- Decision-making and required actions or outcomes are determined hierarchically and top-down (i.e. authoritatively).
- Public participation and, more specifically, actor involvement processes are determined narrowly and passively.
- Power distance, individualism, avoidance of uncertainty, and short-term maximisation (vs. long-term optimisation) are promoted.

- The recurrent generation of structural entities (e.g., infrastructure for water control) results in maintenance costs that exceed their long-term benefits (i.e. 'white elephants').

In this research, the focus societal function is the management of water resources for the purposes of human use and wetland conservation. It is to be noted that the concept of 'regime': (1) constitutes a conceptual category of the socio-institutional sub-system that enables the study of institutional configurations (in this case, a rigid configuration within a maladaptive social-ecological system), including three important components of analytical interest, namely 'organisations' besides 'institutions' and the 'epistemological paradigm' underlying both of them (in this case, a command-and-control paradigm); (2) constitutes a general definition emphasising institutional performance over time; (3) allows a dynamic capability for change, either exogenous or endogenous; (4) does not assume the same causality in the processes of institutional genesis and reproduction, and seeks to avoid structural functionalism (explaining causes by their consequences); (5) operates at a meso level, i.e. between the micro (behavioural relationships in dyads or small groups of individuals) and the macro (outcomes at the broader societal level) levels.

As argued in Chapter 1, Section 1.3, both these propositional conceptualisations and hypothesis h_1 gave direction to the institutional analysis presented in Chapters 5 and 6. In particular, the hypothesis provided a defined 'causal process' (i.e. recurrence of command-and-control and path dependence) and 'outcome objects' (i.e. rigid institutional regime as the pivotal feature of the Doñana maladaptive water socio-ecosystem) to search for along the institutional analysis. Nevertheless, as also argued in Section 1.3, while proof on the recurrence of command-and-control schemes seemed to be strong, proof of the existence of a rigid institutional regime in Doñana was still deemed as weak. Therefore, the two propositions of Doñana as a maladaptive water socio-ecosystem and of the existence of a rigid institutional regime at its pivotal feature were initially established as conjectures. As such, they allowed proceeding to the institutional analysis and to the evaluation of the hypothesis, while concurrently searching for further proof of their existence. The institutional analysis and the evaluation of the hypothesis were performed in two main stages presented in Chapters 5 and 6 respectively, which had as common denominator a core process of theorising that

constituted the confirmatory phase of the research. A succinct description of such process of theorising is presented next, in order to help in better understanding the rationale and content of the theoretical framework described below, as well as the institutional analysis performed in the thesis.

2.3.2. Core process of theorising

The theoretical elements of the theoretical framework that are mentioned in this section have been market in italics. They are described in detail in the subsequent sections of this chapter.

In a first theoretical iteration (Fig. 6), Chapter 5 provides a historical explanation of the current configuration of the Doñana's institutional regime for water resources management and wetland conservation. The explanation is informed by the *Institutional Analysis and Development framework* (Kiser and Ostrom 1982, Ostrom 2005), by elements from *resilience theory* (*adaptive cycle heuristic*, *institutional resilience* and *maladaptive traps departing from the cycle*), and by the concept of *institutional path dependence*. It has two distinguishable parts. First, it explains the deep-historical genesis of the regime at a critical juncture in the 19th century. Second, its explains the regime's formation and continuity up to the last decades of the 20th century, despite its dysfunctionality for coping with repeated social-ecological crisis and its failure to harmonise wetland conservation, water management and economic development. This historical explanation provides a preliminary evaluation of hypothesis h_1 – namely that: the Doñana's institutional regime has followed a *path-dependent* dynamic, characterised by the persistent application of command-and-control policy panaceas. In a seeming paradox, these panaceas, instead of driving the regime towards an efficient outcome, led to the formation of a rigid institutional regime and drove the water socio-ecosystem into a systemic *rigidity trap*. As I shall show, through the magnifying lenses of the theory on *institutional path dependence* this rigid outcome is qualified by theory as unexpected and contingent, for it defies the traditional expectations of *neoclassical economics* that lie at the logical core of the mentioned theory.

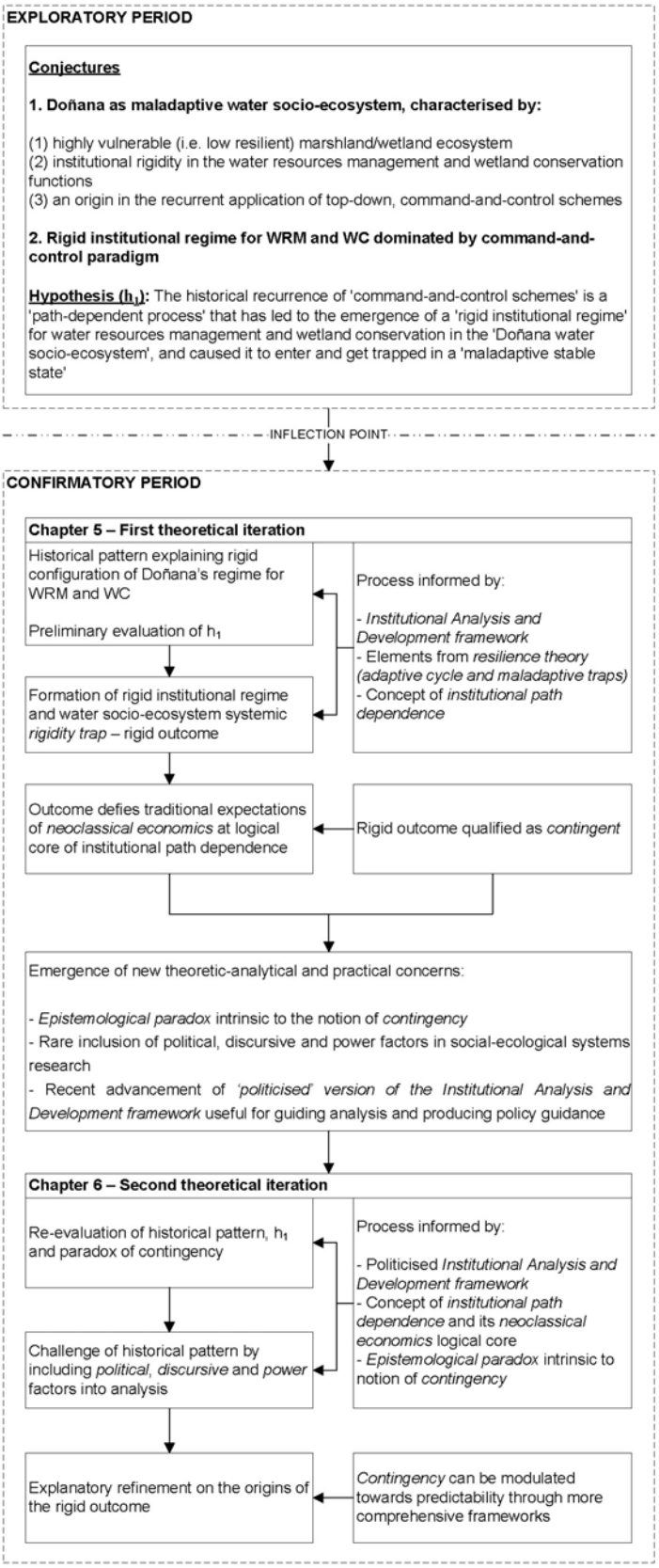

Figure 6. Graphical depiction of the core process of theorising

WRM = water resources management, WC = wetland conservation

Chapter 6, through a second theoretical iteration (Fig. 6), re-examines both the historical explanation developed in the previous chapter and hypothesis h_1, and shows how predictability can be enhanced if contextual components such as *political*, prevailing *discourses* and *power* factors are taken into analysis through a more comprehensive framework. Although that iteration re-evaluates the historical pattern of Chapter 5 and challenges the findings of that pattern, it ends up contributing to its explanatory refinement, hence improving the prospects for enhanced policy guidance. My account of results in both chapters and the general discussion in Chapter 7 progress always with extreme care to differentiate how the different mechanisms posited in the two theoretical iterations have operated over time, and to justify their necessity and sufficiency as conditions for the emergence and stabilisation of the conjectured rigid outcome in Doñana. In the general discussion in Chapter 7 I make the case for the explanatory role of political, discursive and power factors, arising from their capacity for the top-down mobilisation of power, and from their contribution to the formation of local institutional and social-ecological outcomes. More generally, I show how their inclusion in the analysis can modulate contingency away from randomness or unexpectedness, and towards predictability.

The second theoretical iteration was unanticipated. Its carrying out responded to three tightly interrelated, theoretic-analytical and practical interests that emerged along the first theoretical iteration. First, it responded to growing interest in delving in the notion of *contingency* that lies at the heart of *institutional path dependence*; in particular, in an *epistemological paradox* that is raised by such notion, loosely tackled in the literature to date (Mahoney 2000). See Section 2.3.3.2 for a detailed description of the *paradox*. Second, it reflected the criticism raised towards the lack of systematisation into analysis of important contextual factors such as those mentioned above (political, discursive and power factors) in social-ecological research (see e.g., Armitage 2008, Voß and Bornemann 2011, Clement and Amezaga 2013); and more specifically as factors contributing to the historical formation of local social-ecological outcomes. Third, it incorporated recent advancements of a *'politicised' version of the Institutional Analysis and Development framework* (see Clement 2010, Clement and Amezaga 2013). Such framework prescribes the inclusion of the mentioned contextual factors in historical perspective to produce more relevant and comprehensive institutional research, and

provides a clear way for organising analysis and produce policy guidance (for recent applications see e.g., Whaley and Weatherhead 2014).

2.3.3. Path dependence and the paradox of contingency

Path dependence is perhaps the most used concept[3] by theorists from different disciplines concerned with the analysis of history and temporality in their study objects (e.g., economic history, historical institutionalism, political and policy sciences, organisation studies, sociology). Due to this disciplinary diversity, to the high abstractness of the concept and to its challenge to the traditional principles of neoclassical economics, its theoretical significance and empirical applicability have been the subject of a very active and disputed debate for the last three decades (see e.g., Liebowitz and Margolis 1990, Mahoney 2000, Pierson 2000a, David 2001, Schwartz 2004, Page 2006, Vergne and Durand 2010, Dobusch and Schüßler 2012). Therefore, theoretical rigour, conceptual clarity and empirical testability are required in any piece of research referring to and using the concept. This is particularly important for studies of social-ecological systems, where the analysis of path dependence hasn't been fully systematised yet. At the same time, however, covering all the theoretical components, nuances and conflicting issues of this concept would be too extensive a subject for any single piece of investigation. Hence, this thesis relies on a conceptualisation of institutional path dependence that stems from the next short account, which synthesises a general abstraction of path dependence in economics based on an extensive literature review[4].

Contemporary work on path dependence is rooted in the works of Paul David (e.g., David 1985, 1994) and Brian Arthur (e.g., Arthur 1989, 1990) on the economic history of technology and on self-reinforcing economic processes, respectively. Broadly speaking, the concept challenges one of the main assumptions made by neoclassical theory – namely, that technological and economic action always move towards optimal

[3] Path dependence is used interchangeably as a theory, concept, model or heuristic in the literature. I use it here as a concept that is part of a broader theory, with potential use as both a heuristic and a model, at the discretion of the analyst.

[4] Sources consulted include: David (1985), Arthur (1989), Arthur (1990), Liebowitz and Margolis (1990), North (1990a), David (1994), Ikenberry (1994), Hacker (1998), Mahoney (2000), Pierson (2000a), Pierson (2000b), David (2001), Arias and Caballero (2003), Puffert (2004), Schwartz (2004), Woerdman (2004), Sydow et al. (2005), Lewis (2007), Boschma and Martin (2010), Vergne and Durand (2010), Dobusch and Schüßler 2012, Levin et al. (2012).

solutions or designs (i.e. outcomes) that are the most efficient in whatever type of function they are argued to fulfil. This assumption stems from the more general assumption that economic action is characterised ex ante by the existence of movements towards a hypothetical, static and invariant general equilibrium, whose demonstration has been traditionally based on highly abstract, simplified and idealised economic models and solutions. Inefficient conditions and outputs are envisaged as transitory phenomena, and notions of dynamics, are restricted to movements towards equilibrium, which, once reached, leads to stasis. According to this approach, the outcome is predetermined and independent of how the initial conditions and the history of technological or economic development unfolded over past time, i.e. it is path independent, and the role of history and evolution can be disregarded. The process is arguably complex and context specific, but economic action, in general, is assumed to be subject to certain negative-feedback mechanisms (e.g., decreasing returns, competitive pressures, price signals) that offset major changes by reaction and lead the setting, in a linear fashion, towards the predicted optimal equilibrium. Institutions are envisaged as arrangements exogenous to the technological or economic process and their development as driven by a constant, rational search for efficiency by actors seeking to improve their individual welfare, thereby arriving at mutually beneficial, collective outcomes.

The studies on the path dependence of technologies and the economy conform the core of a much more ample critique to the abstract, and rather normative, principles of neoclassical economics. According to this approach, in the absence of exogenous shocks, lock-in will occur on any alternative sub-optimal outcome that diverge from and select out optimal and more efficient, superior alternatives. The main assumption is that outcomes depend on how the initial conditions and the history of technological or economic development unfold over time, because a multiplicity of multiple-stable equilibria or attractors (i.e. limiting distributions) exist at the end of the process. Optimal outcomes form part of the range of multiple attractors, but they are not predetermined, for the process is considered as non-ergodic and independent of the level of consciousness or rationality of the actors[5]. In general, it is argued that the beginning of the process is affected by seemingly small, random events that have an unexpected

[5] Note that this argument is different from the insight of not predetermined optimal outcomes as a consequence of the non-existence of fully knowledgeable and rational actors in the 'real' world.

disproportionate effect on the outcome (i.e. non-linearity) and that the process unfolds in a stochastic fashion. While in the equilibrium approach the assumed mechanisms decrease the probability of distancing from the predetermined optimal outcome, path dependence entails that the probability of occurrence of the sub-optimal outcome increases at each step of the process. This happens owing to 'increasing returns', which deal with the notion of how decisions by actors favouring certain choices (e.g. technology) directly or indirectly increase their attractiveness for other actors, in terms of pay-off or utility. Underlying increasing returns, there are 'self-reinforcing mechanisms', i.e. positive feedback mechanisms that result in a self-reinforcing pattern, (e.g., learning and coordination effects; described in detail in next section).

In this research, these phenomena are studied in combination with notions from the concept of "critical junctures" (Collier and Collier 1991). According to that notion, the conjectured Doñana's rigid institutional regime for water resources management and wetland conservation might have been impacted, at a certain point in history, by the effect of a "critical juncture", i.e. strong systematic forces that might have had fundamental impacts on the regime's subsequent dynamics (Thelen 1999). Depending on the way they occur, they may produce radical or incremental changes that result in a diversity of institutional configurations, therefore shaping large political or economic development in the long run (Collier and Collier 1991, Hacker 1998, Mahoney and Thelen 2010).

2.3.3.1. Path dependence in studies of institutions and politics

Path dependence was soon applied by Douglass North to study the dynamics of formal and informal institutions (North 1990a, 1991). North generalised path dependence as a core concept in explanations of institutional differences between diverse social and economic systems showing an unexpected stability in spite of a history of poor performance, in economic terms. He argued that institutions are subject to the same self-reinforcing mechanisms as technological and economic processes, in particular, to what he terms as "massive increasing returns" (North 1990a, pp. 94-95). However, contrary to Arthur's views, North considers the latter as a necessary but not sufficient condition for path dependence. For him, the lock-in of sub-optimal outcomes prevails regardless of the efficiency of alternative institutional configurations, due to other conditions such

as the prohibitive transaction costs of switching or reversal, the imperfection of the market, and the limited rationality of the actors (North 1990a, p. 95). The advancements of David, Arthur and North, where then applied in political science (e.g., Pierson 2000a) and historical sociology (e.g., Mahoney 2000), in perhaps two of the most rigorous attempts "to build a general theory of some form of institutional path dependence" (Woerdman 2004, p. 56).

However, certain incomplete analogies must be made explicit when path dependence concepts are transported across disciplinary levels (Woerdman 2004, p. 58). My thesis applies the analogy to increasing returns made by Woerdman (2004), based on North's insight. That analogy, which Woerdman argues as incomplete, is made from technology and economics to institutions, as follows. Economic increasing returns imply that the production costs of a technology declines as fixed costs are spread over an increasing production volume. For institutions the analogy is not an increased production of institutions (e.g., rules, legislation), but the decreasing costs of adding them as "the institutional scale increases" (Woerdman 2004, p. 61), as well as the increasing potential benefits that this phenomenon signals to lower-level actors.

The self-reinforcing mechanisms[6] underlying increasing returns are defined in this thesis as: (1) large setup or fixed costs, which create a high pay-off for further investment in an already established single option; (2) learning effects, if knowledge gained in the recursive operation over the resource system or ecosystem lead actors to be more efficient and get higher returns from continuing use; (3) coordination effects, if the individual benefit increases as others adopt the same option; (4) adaptive expectations, where increased prevalence of selected options enhances beliefs of further prevalence (adapted from Arthur 1988, North 1990a). I shall return to this below. Now, in order to build the core of my argument I shall introduce the concept of contingency and the epistemological paradox that it creates in studies of path dependence.

[6] Self-reinforcing mechanisms are the "set of mechanisms endogenous to a given path that makes it more and more dominant over time relative to alternative paths" (Vergne and Durand 2010, p. 755).

2.3.3.2. Contingency: an epistemological paradox

Contingency and its assumptions have a diversity of meanings and nuances. According to the literature review of Ballinger (2013), contingency can signify a number of different meanings such as: 'dependence upon'; 'chance and accident' being as relevant as structure; the 'freewill' of agents; 'qualities' existing in only some possible worlds as part of the set of all possible worlds which share necessary qualities; a 'conjuncture of events' without perceptible design; 'events' that set structural entities (e.g., institutional patterns) with deterministic properties in motion; a 'component of chaos theory', such theory reconciling contingency with the notion of causation. In this research, I am concerned with a very specific epistemological tension also recognised by Ballinger, between two senses of contingency rarely specified in studies of path dependence. I establish such tension based on Mahoney (2000, p. 513), as follows: contingency refers to (1) the "inability of theory to predict or explain, either deterministically or probabilistically, the occurrence of a specific outcome", hence a contingent event is "an occurrence that was not expected to take place, given certain theoretical understandings of how causal processes work"; (2) that some events or behaviours are part of a "non-systematic variation inherent in the world that cannot even in principle be eliminated from causal theories"[7]. Generally speaking, any event, behaviour or outcome at odds with analysis is assessed as contingent because it appears as either unforeseen by the set of general principles or propositions of the epistemological device at work (e.g., analytical framework, theory, model), or random phenomena of an inherently stochastic world (e.g., chance, freewill, agency, natural disasters).

And herein lies the paradox, for whose articulation I rely again on Mahoney (2000, p. 516), but with a different perspective, in pursuit of a more general implication. For him, the combination of the indeterminism characterising contingency in the genetic phases (e.g., critical junctures) with the determinism of the mechanisms leading to the reproduction of the outcome in a self-reinforcing path-dependent sequence, lead to a paradox, since such outcome simultaneously: (1) contradict the analytical framework at work; (2) is reproduced through mechanisms associated with the very contradicted

[7] Ballinger (2013, p. 15) argues that Mahoney (2000) obscures assumptions concerning determinism and indeterminism by establishing that path dependency is "marked by contingency". However, I argue that Mahoney is overtly pedagogic and that he simply does not further pursue the implications of his notion of contingency, what I intend to do in this research.

framework. Although he speaks generally about prevailing analytical frameworks and different disciplines, he exemplifies about the path dependence of technologies or the economic process and their organisations (e.g., QWERTY vs. Dvorak keyboards, mass vs. craft production). There, the outcome is assessed as contingent because it appears to contradict the principles of neoclassical economics. Broadly speaking, the efficiency of either technologies, economies or institutions is called into question in an assessment against the principles of models portraying an ideal world in which optimality is achieved in a state of equilibrium. To make sense of the paradox, he argues, it must be recognised that (1) the outcome results contradictory when it is compared with past alternatives, which were viable at the earliest part of the path-dependent historical sequence and, from a neoclassical standpoint, seemed as more efficient and optimal choices; and (2) although a sub-optimal, far-from-equilibrium and inefficient outcome is produced instead, such outcome is reproduced at present by neoclassical-theory mechanisms. In other words, the key of this seeming paradox lies in that explanations about the lock-in phase rely on the same, negative feedback mechanisms associated with neoclassical theory (e.g., constant or decreasing returns), which are contradicted by what is occurring at the initial (e.g., randomness, unpredicted or illogical behaviour) and self-reinforcement (e.g., increasing returns) phases, i.e. by actual events or behaviours. In the institutional realm, this focus on neoclassical economics, in particular, on its utilitarian core, results in a failure to theorise different mechanisms explanatory of institutional dynamics (Mahoney 2000, pp. 525-526).

In my view, this paradox has a higher implication at an epistemological level, with both theoretical and normative repercussions[8]. I argue that the two significations identified by Mahoney in studies of path dependence are two attributes representing two extremes of contingency, one referring to pure randomness or chance, and another, to pure predictability[9]. Between both, a continuum of predictability unfolds, with randomness equating a high level of unpredictability[10]. Since events or behaviours that are observed as random or unexpected under certain epistemological devices might be straightforwardly explicable or predicted by alternative devices, randomness might

[8] The issue at stake is much more ample and complex. However, for the purposes of building the main argument of this thesis, I have simplified the issue.
[9] See Eagle (2005) and Ballinger (2013) for two excellent accounts on these issues.
[10] I must note here that my construction of this issue neither preclude the existence of regularities in sequences of events with uncertain outcomes, nor exclude the possibility to describe certain phenomena or evolution of events through probability distributions.

reveal and be more properly assessed as unpredictability to some degree. In other words, that the outcome under analysis is assessed as contingent by certain theoretical notions, doesn't mean that its emergence cannot be consistent with the expectations of alternative theories positing causal links accounting for such outcome. In consequence, assessments of randomness and unexpectedness, or global contingency, might simply constitute an epistemic mirage determined by the shortcomings of the epistemological device at work or by a lack of perspective (or analytical myopia) on the part of the researcher. In any case, it renders in the latter's incapacity to explain or theorise about certain past or present phenomena that are significantly constraining future time and decisions.

The corollary of this argument is that, in general, the recurrent use of common, enhanced epistemological devices could result in systematic movements away from premature assessments of randomness and towards (un)predictability, hence to augmented predictive power. In particular, such systematisations in studies of path dependence would result in an enhanced capacity to inform the assessment of both the initial phase (as random or proceeding by chance) and outcome (as globally contingent, i.e. as a bizarre object under a pure neoclassical lens). Contingency, under this perspective, ought to be envisaged as a 'modulable property' of path dependence that ranges between randomness and predictability, hence a question that emerged from the findings made through the historical pattern (Chapter 5): Can we modulate contingency away from randomness and assess it as unpredictability, thus turning certain outcomes into more predictable objects by using more comprehensive epistemological devices? While answers might differ depending on the preferred philosophical orientation (e.g., positivist, post-positivist) of the researcher, I am discussing an issue that I deem as shared by different approaches to social research[11].

I shall turn now to describe how politics, power and discourses shape the concept of path dependence. The issues dealt with in the next section have been raised in the field of social-ecological systems, largely unrelated to the concept of institutional path dependence and to the epistemological paradox created by the notion of contingency.

[11] This research also serves the purpose of informing the debate separating the significance of contingency in social science, particularly in historical explanations of social phenomena, from the core significance that it has in biological evolution (see Gould 2002).

Moreover, the analysis of political, power and discursive factors is still scarcely systematised in such field.

2.3.3.3. The role of politics, power and discourses

In institutional, political and sociological studies, the core logic of path dependence in technology and the economy constitutes only the utilitarian argument of the discussion, there being other mechanisms at stake. Indeed, due to the existence of actor constellations, other mechanisms are also posited as bearing explanatory power in institutional dynamics, and for questions of inefficiency and sub-optimality. These mechanisms include: asymmetric power relations, functional logics, legitimacy claims, the accumulation of mutual commitments, the complex compound of inherited institutions, and the significance of collective action (Mahoney 2000, Pierson 2000a, 2000b). They can be classified generally as functional, power and legitimation mechanisms, and contrasted to utilitarian mechanisms (Mahoney 2000, p. 517). From the standpoint of political science, institutional dynamics are not just determined by mere rational responses to a series of inefficiencies that are seen as transitory, but also by political struggles over different interests and distributions of power. North soon acknowledged the role of political organisations, hence power in institutional dynamics (North 1991). For Pierson (2000b, p. 77), political actors, seeking to reinforce their authority and power, might favour and induce further movement along a particular path by influencing public policies and institutions. In contrast to the view of institutional conditions in an inertial state of irreversibility, the political view of path dependence emphasizes more how present and future possibilities of change are the residue of a richer set of past alternatives at the initial conditions, most of which are no longer available (Pierson 2000b). Institutional dynamics are envisaged as restricted and change as bounded by mechanisms (e.g., counter-reactions) grinding down other mechanisms that would otherwise lead to reproduction and continuity (Pierson 2000b). Power asymmetries inherited from past institutions result, in practice, in an array of opportunities and constraints influencing the nature of governance and the calculation of rulers (Lewis 2007, pp. 42,48).

While some authors focus more on the determinism of path dependence, and assign agency a secondary role (Mahoney 2000, Pierson 2000b), North (1991, p. 98) stresses

the existence of choice points along the path, at which actors have the opportunity to mobilise in support of a preferred choice, therefore loosening the automaticity of path dependence development. Others have furthered the theoretical claim that increasing returns "do not happen automatically" and must often "be cultivated by actors", through the mobilisation of power and ideas that promote their interests and play a role in the process of institutional change or stabilisation (e.g., mobilisation in the political arena on behalf of policy or regulatory change, organisation of collective action, coalition building) (Deeg 2001, p. 12-13). Utilitarian mechanisms such as increasing returns may get exhausted and be replaced by power or coercive mechanisms (e.g., state-enforced monopolies, delegated enforcement powers) activated by dominant actors to reproduce institutions so as to retain their positions (i.e., to maintain the status quo), until the advent of "decreasing returns" force them to arrange new institutional configurations (Schwartz 2004)[12]. In fact, some have argued that political conflict, especially conflict over ideas and underlying assumptions about policies or institutions, do have a primary role in explanations of institutional dynamics (Peters et al. 2005). More generally, it is argued that institutional dynamics require a theory of ideology accounting for deviations from the predictions of neoclassical economics (e.g., altruistic behaviour, obedience, inefficiencies) in which 'context, culture and ideas' are not uncritically reduced to simply 'how information is distributed and used' (Fine 2000). Indeed, more than three decades ago, North argued that assumptions of economic rationality in neoclassical economics cannot account for certain phenomena (North 1981, p. 11) and turned to the development of a theory integrative of the role of ideology in institutional dynamics and economic change (North 2005).

All these concerns have been raised among scholars analysing social-ecological systems as well (see e.g., Pritchard and Sanderson 2002, Armitage 2008, Smith and Stirling 2010, Pelling and Manuel-Navarrete 2011, Voß and Bornemann 2011, Clement and Amezaga 2013), but they have been seldom systematised into analysis, in general, or in the context of institutional path dependence, in particular. In this thesis, I make the case for the explanatory role of discourses (understood as a conveyance of ideas and knowledge) and of political-economic interests, as contextual factors that mobilise power top-down and contribute to the formation of a local rigidified outcome. For this

[12] If they do not, then we may see a path change without any obvious exogenous cause (Deeg 2001, p. 12, footnote 15).

purpose, I treat such contextual factors following the 'politicised' version of the Institutional Analysis and Development framework (Clement 2010, Clement and Amezaga 2013). My specific concern is how the inclusion of both a higher analytical tier and a specific theoretical content stemming from the new components, in the analysis, can help to modulate contingency, as conceived above. In doing so, it is important to emphasise that the thesis' is a multi-level approach, not an exclusive focus on the politics of path dependence. Although the research borrows from theoretical work on path dependence in politics (e.g., Pierson 2000a), it does not work exclusively on a non-economic, political situation, hence it explicitly avoids a simple translation of the concept to the political arena.

2.3.4. The adaptive cycle, institutional resilience and maladaptive traps

Evidence from case studies of regional development and resource use has shown that complex adaptive systems undergo cyclic, multistate catastrophic behaviour (Levin 1998), which fits an adaptive four-phase cycle characterised by structural changes in three key descriptors of the system's properties: potential, connectedness and resilience (see Fig. 7 for a graphical depiction; Table 2, for a detailed description of the properties of each phase) (Holling 1986, Gunderson et al. 1995, Gunderson and Holling 2002). Although the adaptive cycle is a heuristic that was originally applied to resource systems and ecosystems, it has been generalised to coupled social-ecological systems and single social systems (e.g., institutional regimes) that undergo, in principle, similar phases (Holling and Gunderson 2002, Allison and Hobbs 2004, Cumming and Collier 2005, Walker and Lawson 2006, Beier et al. 2009, Bunce et al. 2009, Daedlow et al. 2011).

In this thesis, I postulate that the Doñana's regimes for water resources management and wetland conservation fitted the adaptive cycle at least once along their history. Therefore, the structural changes in the system's descriptive properties (potential, connectedness and resilience) can be used to describe the forces that shaped the behaviour of such regimes.

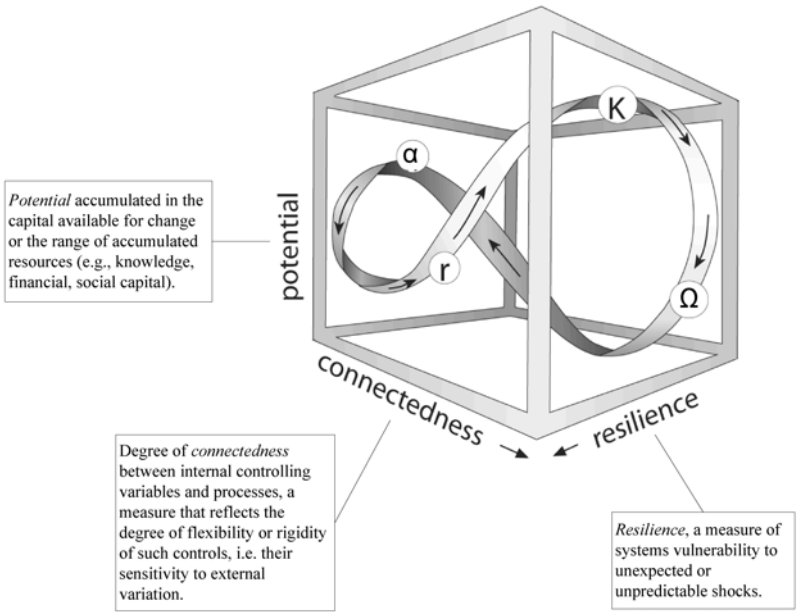

Figure 7. The adaptive cycle

Source: modified from Holling and Gunderson (2002) with permission from Island Press, Washington, D. C., USA

The meaning of resilience, in particular, can be approached from two different perspectives: 'engineering resilience' and 'ecological resilience' (Holling 1973, Holling 1996). The first focuses on the notion of time for recovering after disturbance, i.e. returning to equilibrium (Walker et al. 2004). The second focuses in the probability of multiple-stable states, and is defined as the capacity of ecosystems "to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks", a definition that may be applied to the social-ecological system as a whole (Walker et al. 2004). From the latter, I derived a definition of 'institutional resilience' that is instrumental for the purposes of this research: the capacity of institutional regimes to withstand external disturbances (e.g., environmental perturbation, political changes) without loosing the performance capacity for the accomplishment of the societal function that they were devised for (after Adger 2000, Carpenter et al. 2001, Perrings 2006, Baral et al. 2010, Smith and Stirling 2010).

I also postulate that an adaptive cycle can collapse into extreme states characterised by combinations of the three descriptive properties, which result in sharply constrained variability and limited opportunity, i.e. into maladaptive cycles (Holling et al. 2002, p.

95). The three properties can be given low and high levels, and from the eight possible combinations that result, four can be suggested as maladaptive states, namely: the poverty trap, the rigidity trap, the lock-in trap, and the chaos trap (after Holling et al. 2002, Allison and Hobbs 2004, Loring 2007). The attributes and properties of these four traps have been described in Table 3.

Table 2. Description of the four phases of the adaptive cycle and the associated changes in the system's descriptive properties: potential for change, connectedness, and resilience

Phase	Description	Potential for change	Connectedness	Resilience
α (reorganization)	- System widely opened to reorganisation - Experimentation and initial establishment of actors, organizations and institutions, strongly subjected to evolutionary forces (i.e. competition, failure, survival) - Loss of resources (e.g., energy, information) is minimised, so that they become available in r phase (legacies) - Great uncertainty about options for the future and chance for unexpected forms of renewal	Relatively high for future development	Low. Internal regulation and control over external variability is weak	High. Wide stability region and weak regulation around equilibrium
r (exploitation and rapid growth)	- Innovators perceive unlimited opportunity - Bases for entrepreneurial and market competition are settled - External variability remains, favourable to entities more adapted to it (r-strategists) - Incremental exploitation of available resources and growth - Actors develop capacity for controlling external variability, hence reinforcing their own expansion - Future starts to be more predictable	Decline as resources start and continue to be exploited	Still low, but starts to increase, along with stability	Remains high due to the adaptation to high variability
K (consolidation and conservation)	- Growth rate slows down - Reduced opportunity and difficulties for new entrants - The future seems ever more certain and determined - Competitive edge shifts to those that control variability (K-strategists) - Increasing returns from efficiency (e.g., minimising costs, streamlining operations) - Organizations become bureaucratised, rigid and internally focused (i.e. blind to external changes)	It turns high again in terms of stored capital	Increases as system becomes highly stable and over-connected in structural and organisational terms, hence more rigid (less flexible)	Rapidly decline, i.e. vulnerability to external disturbance starts to increase
Ω (release)	- Extreme structural rigidity that may trigger sudden change, collapse and a 'creative destruction' phase (Schumpeter 1950) - Chaotic behaviour, uncertainty rules govern - All of these create the source for reorganisation and the systems begin to acquire a new identity	Suddenly decline as previously accumulated resources are abruptly released and exhausted	High, but connections and regulatory controls are suddenly broken	Low, but rapidly increases as the system moves towards the next Ω phase of reorganization

Source: based on Gunderson and Holling (2002)

Table 3. The level of each of the three variables that characterise the four maladaptive states and their descriptive attributes

Maladaptive state	Potential	Connectivity	Resilience	Descriptive attributes
Poverty trap (Holling et al. 2002)	Low	Low	Low	- Potential and diversity have been eradicated by misuse or by an external force - Highly productive ecosystems (e.g., wetlands, savannah) have been overused and misused, and flipped into an irreversible state of degradation - Local society has been deeply affected by social disruption or conflict, where cultural cohesion and adaptive abilities have been lost - Individuals can depend only on themselves or family members - Such societies exist in a degraded state of bare subsistence, barely able to persist but unable to accumulate enough potential to form larger structures and sustaining properties - They might collapse in anarchy
Rigidity trap (Holling et al. 2002)	High	High	High	- The system has potential for sustainable performance, but is maladaptive - Great ability to resist external disturbances and persist - Potential is measured in accumulated wealth - Connectedness comes from efficient methods of social control whereby any novelty is either smothered or sees innovators ejected - System controlled by unchangeable, disciplinary administrations - High vulnerability to change and surprise - Command-and-control have squeezed out diversity, and power, politics, and profit have reinforced one another
Lock-in trap (Allison and Hobbs 2004)	Low	High	High	- Biodiversity has been deeply eroded due to socioeconomic development (e.g., commodity production) - Productivity and ecosystem functions pose high costs, requiring complex management strategies - Important system components involved with the hydrological cycle have been irreversibly modified at a regional level - There are signs of resource depletion, environmental pollution and social decline - The system has so much "sunk-costs" that it may continue to degrade the resource it relies upon until the capital is totally removed
Chaos trap (Loring 2007)	High	Low	Low	- The system have the potential for diversification - Lack of connectivity and resilience prevent any particular combination from asserting itself, especially when faced with minor perturbations

Source: based on Holling et al. (2002), Allison and Hobbs (2004), Loring (2007)

2.3.5. The Institutional Analysis and Development framework

The Institutional Analysis and Development framework (IAD hereafter; Kiser and Ostrom 1982, Ostrom 2005) focuses on the relationship between institutions and human behaviour and action (Fig. 8). Broadly speaking, within the IAD institutional arrangements are understood as "the rules used by individuals for determining who and what are included in decision situations, how information is structured, what actions can be taken and in what sequence, and how individual actions can will be aggregated into collective decisions"; institutions are thus "complex composites of rules, all of which exist in a language shared by some community of individuals rather than as the physical parts of some external environment" (Kiser and Ostrom 2000, p. 56).

The focal level of analysis of the IAD is the 'action arena' (Fig. 8), defined here as the social space where: (1) policies or institutions are designed by 'actors' engaged in action situations[13] affected by the 'biophysical conditions' and by two social variables reflecting the most substantive part of a pre-existing institutional framework, namely, 'rules-in-use' and 'attributes of the community'; (2) the patterns of interactions and decisions that take place within the action situations shape certain outcomes; (3) such outcomes feedback into the action arena and into the mentioned variables, and may change the institutional framework (Ostrom 2005, McGinnis 2011). In sum, actors use institutional prescriptions to organise repetitive and structured interactions while participating in action situations within the action arenas. Institutions are considered as an exogenous variable of the arena, the other exogenous variables being the biophysical system being acted upon and the cultural attributes of the community.

[13] According to McGinnis (2011, p. 172), originally "the action situation was enclosed within an action arena, which also included the set of actors as a separate component; however, since the capabilities of actions can be attributed to the effect of the position rules defined below, E. Ostrom (2010) recommends abandoning this distinction between action situation and arena". This thesis keeps the original formulation of the action arena, since it better addresses the systemic needs of the present research. In particular, it globally captures the diversity of combinations of rules, situations and actors that can emerge at the different levels of analysis defined by the IAD, namely: constitutional, collective-choice and operational (see below in main text).

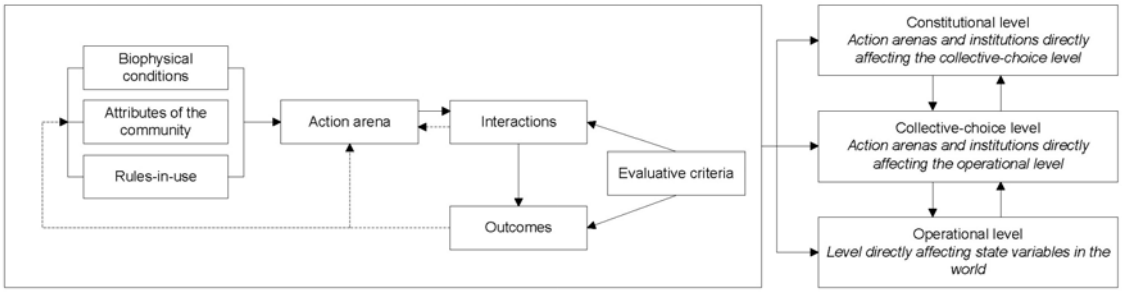

Figure 8. The Institutional Analysis and Development framework

Source: modified from McGinnis (2011)

This research relies on the following general definition of 'institutions' (based on North 1990a, Ostrom 2005, McGinnis 2011):

The human-devised regular patterns of constraints or opportunities within which the choices, actions and interactions of actors (individual or organisational) take place and which shape the consequences of such choices, actions and interactions – in short, the formal and informal rules of the game.

This definition of institutions is applied to the variable 'rules-in-use' of the IAD. In turn, epistemological paradigms (e.g., command-and-control schemes, other scientific-technical approaches, traditional ecological knowledge) are considered as the observable element of the variable 'attributes of the community' for understanding the formation of institutional regimes. I therefore left out the more general concept of culture pivotal to that variable, since it constitutes a very broad and relevant concept considered as an institution itself by sociological disciplines (see Hall and Taylor 1996). Regarding the variable 'biophysical conditions', here it is matched with the hydro-ecological system of Doñana, composed by its water resources, hydraulic system and marshland/wetland ecosystems.

Regarding actors, the IAD depicts them as "fallible learners" (McGinnis 2011), i.e. as operating under uncertainty, and having limited cognitive and information-processing capability (bounded rationality[14]), but as being able of learning from error (adaptive

[14] This view of the actor, in particular, "bounded rationality" (Simon 1955), is reactive to the view of rationality as optimisation of neoclassical economics.

learning). For the purposes of this research, they are considered either as individuals acting on their own or as agents of 'organisations'. In line with the concept of institutional regime, I differentiated between institutions (e.g., rules, norms) and organisations (e.g., research and management agencies; see also Ostrom 2005, p. 179). Organisations constitute specific ensembles of individuals with common interests, values or beliefs whose formation respond to the institutional framework, or to other constraints or opportunities such as technology or biophysical conditions (based on North 1990a, p. 73; see also North 1990b).

Finally, the IAD poses a multi-layered hierarchical structure of three tiers for organising institutional analysis, termed 'constitutional', 'collective choice' and 'operational' (see Fig. 8). These levels constitute a hierarchical, multi-level structure, in which each upper tier determines how institutions and decisions are made at the next, downward level. The lower levels can, in turn, exert an influence over the upper levels. The lowest, operational level directly affect state variables in the world and was the initial focus of my research (see e.g., Ostrom 2005, p. 59). The use of these levels varied as the research progressed, showing an increased focus on the higher levels (i.e. collective-choice and constitutional). These changes are indicated were appropriate. A figure depicting how the IAD was applied to the Doñana case is included in Chapter 5.

2.3.6. The 'politicised' Institutional Analysis and Development framework

This section describes the 'politicised' version of the IAD (p-IAD hereafter; see Clement 2010, Clement and Amezaga 2013), focusing on the most relevant aspects of the extensions proposed by that device for this research. Regarding power, the p-IAD (Fig. 9) combines Lukes' (2005) third-view and Foucault's (1979) conception. It does so to grasp "the micro forms of power that are made, transformed or sustained by institutions" in the daily enforcement of social and political practices, so as to capture how power is dispersed across society (Clement 2010, p. 135; see also Clement and Amezaga 2013, p. 147). Using this approach, I was particularly interested in how power is distributed at high governance levels and how it subsequently impacts lower governance levels.

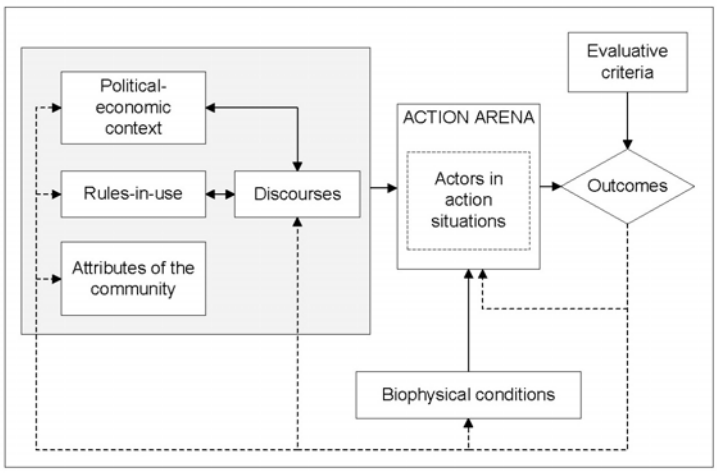

Figure 9. 'Politicised' version of the Institutional Analysis and Development framework

Source: modified from Clement (2010) and Clement and Amezaga (2013)

Based on Hajer and Versteeg (2005), Adger et al. (2001) and Clement (2010), I defined discourses as:

Homogeneous and organised regularities of categorisations and concepts conveying ideas, knowledge or meaning about objects from the world, which actors exchange through oral or written interactive means.

This definition of discourses seeks to emphasise a twofold property of this concept: (1) to constitute objects through homogeneity in message (e.g., regularities in the form of a knowledge system); (2) to produce such objects through interactive, expressive means (e.g., arguments, accounts, stories, narratives, speeches; see e.g., Keeley and Scoones 2000, Adger et al. 2001). The definition was specifically tailored for its application in the context or social-ecological systems, and open to both rigorous empirical evaluation and future developments. Within it, I conceive the term 'world' as interchangeable with other objects of study, such as the more particular term 'social-ecological system'. The specification of the philosophical roots of the selected approach to define 'discourses' and 'discourse analysis' is a necessary exercise to allow for productive debates in any methodological context, due to the diversity of approaches competing to appropriate these two terms for their own conceptualisations (Jorgensen and Phillips 2002). In this case, I approached analysis from the common ground of structuralist and post-structuralist linguistic philosophy. This common ground conceives our access to reality

as largely mediated by discourse (as language), which is used to create representations that are both reflections of such reality and contributions to its creation (Jorgensen and Phillips 2002, p. 5).

Therefore, discourses are envisaged here as homogeneous, versatile and overarching patterns of thought and language-in-use that contain the knowledge or meaning of actors about certain world phenomena, as well as about the causality of problems and adequate responses to them (e.g., through certain courses of action and practices); while also recognising the capability of actors to dynamically convey discourses, thus contributing to the production of objects and subjects in the world. Discourses exert power because "they transport knowledge on which collective and individual consciousness feeds. This knowledge is the basis for individual and collective, discursive and non-discursive action, which in turn shapes reality" (Jäger and Maier 2009, p. 39).

This conceptualisation is compatible, on the one hand, with the notion of the actor as a fallible learner of the original IAD device; on the other, with the p-IAD's view of discourses as constitutive of institutions, owing to their capacity to reinforce or undermine their credibility, i.e. to confer power to institutions (Clement 2010). Because discourses have actors' values and beliefs built-in, they hold a capacity to mobilise power, thus acting as drivers of policy and institutional dynamics; and they are, in return, shaped by the political-economic context and the pre-existing institutional practices in which they are embedded, in a dynamic two-way interaction (Clement 2010, Clement and Amezaga 2013). It must be emphasised that (although relevant for it) the focus is not on discourse theory, but on discourses as one more analytical component with causal power over the focal outcomes observed at present. Indeed, discourses hold a capacity for illuminating explanations (e.g., mechanisms at work, answering of 'how' questions, see Hajer and Versteeg 2005; see also Schmidt 2010, p. 21)[15]. A figure depicting how the p-IAD was applied to the Doñana case is included in Chapter 6.

[15] In particular, Schmidt (2010) makes a strong case of discourses as holding great analytical power to understand and explain institutional dynamics, resting upon insights from the 'new institutionalism' schools of thought. Indeed, she puts forward the existence of a new school of institutionalism thought, namely a "discursive institutionalism".

2.4. Mode of thinking and inference procedure

The IAD was originally defined as a framework in contrast to theory (Ostrom 2005, pp. 27-28). According to Ostrom (2005, p. 28)[16]:

- Frameworks are at the most general level of theoretical analysis, organising diagnostic and prescriptive enquiry. They help researchers to generate relevant research questions, and to identify the most general set of variables and relationships that must be considered for analysis in a diversity of institutional settings. These variables constitute the universal variables that relevant theories need to include. Frameworks provide a metatheoretic language that is necessary to talk about and compare such theories, facilitating the discussion of potential differences in surface reality that can result from distinct combinations and interactions among variables.
- Theories, in turn, are more specific devices that causally link observed or modelled phenomena, providing analysts with interpretive structure. They enable to specify the framework's components that are relevant for certain kinds of questions and to make assumptions that are necessary to diagnose a specific phenomenon, explain its processes, and predict outcomes. Multiple theories are usually compatible with one framework, although empirical research should narrow the range of applicable theories over time by showing the superiority of the remaining theories to explain data.

In this research the IAD and its extended version, the p-IAD, were not used in an orthodox way[17]. They were used as diagnostic and prescriptive devices in both the institutional analysis and the process of theorising. However, they were applied in an double-headed form to enhance their capacity for understanding and explaining the complexities inherent to the research's objects of study, namely: the conjectured Doñana's rigid institutional regime and maladaptive water socio-ecosystem.

On the one hand, they were applied according to McGinnis (2011), whose definition of institutional analysis is most useful for this research. According to him, the IAD

[16] I have excluded Ostrom's (2005, p. 28) definition of a model, since no model is used in this thesis.
[17] Actually, the IAD framework does not impose any procedure neither for conducting analysis, nor for theoretical development; that choices are left to the discretion of the analysts.

categorises relevant explanatory factors and locates them within a foundational structure of logical relationships that allows for the "decomposition of institutional contexts into their component parts as a prelude to understanding how these parts affect each other and how institutions shape outcomes" (McGinnis 2011, p. 170). On the other hand, both the IAD and the p-IAD were used as analytical devices enabling 'complex systems thinking', a mode of reasoning that stems from complexity science (Kay et al. 1999, McCarthy et al. 2011). As opposed to reductionist scientific approaches, complex systems thinking addresses and embrace the inherent complex and uncertain nature of social-ecological systems. It does so with the help of certain theoretical and methodological devices (e.g., adaptive cycle heuristic; see Section 2.3.4) aimed at guiding and informing the understanding, description and even the prediction of their dynamics and behaviour, in stark contrast to the linear arguments of reductionism (McCarthy et al. 2011). Additionally, the practice of complex systems thinking in the policy and institutional realms serves to build resilience and to foster adaptive capacity in social-ecological systems (McCarthy et al. 2011).

Here, the IAD and p-IAD were applied as devices enabling an internalised complex systems thinking mode in line with soft systems methodologies (Checkland and Scholes 1990), as contrasted with a stage-by-stage use of the frameworks. This thinking mode allowed for easily making sense of the complex problems being assessed throughout the thesis. It was used at all stages of the research, but it is fully implemented in the research presented in Chapters 5 and 6, i.e. along the institutional analysis and the core process of theorising of the thesis. There, it was systematised as follows.

In the research presented in Chapter 5, the IAD, acting as an analytical spearhead, allows to build a rich historical explanatory pattern (*explananda*) about 'why' and 'how' the conjectured Doñana's rigid institutional regime and maladaptive stable state (*explanandum or outcome*) has emerged and stabilised. In Chapter 6, using the p-IAD, I challenge that historical explanatory pattern and refine it as described in Section 2.3.2. At both research stages, the analytical task consisted in tracing 'mechanisms' productive of the conjectured outcome. The concept of 'mechanism' is understood here as in the life sciences, applied to socio-institutional phenomena. In particular, mechanisms are understood as phenomena "organised such that they are productive of regular changes

from start or set-up to finish or termination conditions" (Machamer et al. 2000, p. 3). To produce explanations:

> *"…one often begins the search for mechanisms with a ready-made layout of the space of possible mechanisms, and the goal is to use empirical findings to eliminate regions of that space. The nature of the phenomenon and the store of accepted mechanism types thus work together to frame the discovery problem: to reveal the layout of the space of possible mechanisms and perhaps to tell one how to decide among them."*(Craver and Darden 2013, pp.67-68).

In this research, the 'space of possible mechanisms' was delimited by the theoretical framework. Inferentially, the analytical and explanatory tasks consisted in reasoning backwards departing from an institutional and social-ecological system outcome, historically contextualised through the hypothesis, under the restrictions of the logical expectations stemming from the propositions and concepts of the theoretical framework. This way of reasoning adjusts to an essential form of retroduction, a procedure through which events or outcomes are explained ex post "by postulating (and identifying) mechanisms which are capable of producing them" (Sayer 1992, p.107, for the origins of the procedure see Peirce 1931-58). From a philosophical standpoint, retroduction is a realist inference procedure that helps scientists to realise, internalise and optimise the dynamic interplay between deduction and induction processes (Hanson 1961). This applies for case-study research, which also acknowledges induction and deduction as interacting procedures along theory testing and development. In that sense, retroduction is understood as "the circular process by which the researcher tests his or her theoretical ideas against the emerging data, reframes the ideas, and retests until the conclusions reached are deemed trustworthy" (Mills et al. 2010, p. 236).

At each research stage, data analysis, inference and theorising were approached through the careful construction of the accounts including the interpretations and explanations about the case. This construction process was never linear; it was, in every case, iterative, relying upon a back-and-forth fashion between data collection and data analysis-interpretation, for a progressive familiarisation with the data, while looking for evidence and patterns that matched or mismatched the theoretical propositions and assumptions under evaluation. In Yin's (2009, p. 143) words the "evidence is examined,

theoretical propositions are revised, and the evidence is examined once again from a new perspective in this iterative mode". The composite of patterns and causal links that compose my theoretical framework were complex and difficult to measure precisely (e.g., more variables of interest than data points). To ease this process, the diagnostic and analytical capacities of the IAD and, by extension, the p-IAD, were invaluable. Another crucial task in which the IAD showed invaluable was in helping to tackle the issue of institutional path dependence and contingency. In particular, it enriched the analysis and interpretation of the issue of rationality and human action in Doñana, thanks to its conception of actors as adaptive learners. Finally, other invaluable feature of the IAD device, preserved by the p-IAD that made it most appropriate for the research is its neutral, versatile and non-normative character.

2.5. Concluding remarks

This chapter has described the methodology developed to accomplish the main research aim and the specific objectives of the thesis. The establishment of the methodology was guided by three principles, namely: (1) defining methodology as a strategic guideline to both organise and enable the examination of the rationale of its components; (2) making a continuous effort for 'being scientific', i.e. to work under the principles of the scientific method; (3) a qualitative research design. This chapter has also described the elements composing the methodology, namely the single-case study design, action research, theoretical framework, and main mode of thinking and inference procedure. The rest of the methods are very specific to each of the four research stages, so they are described in greater detail in their respective chapters (see Fig. 10 for an overview of methods).

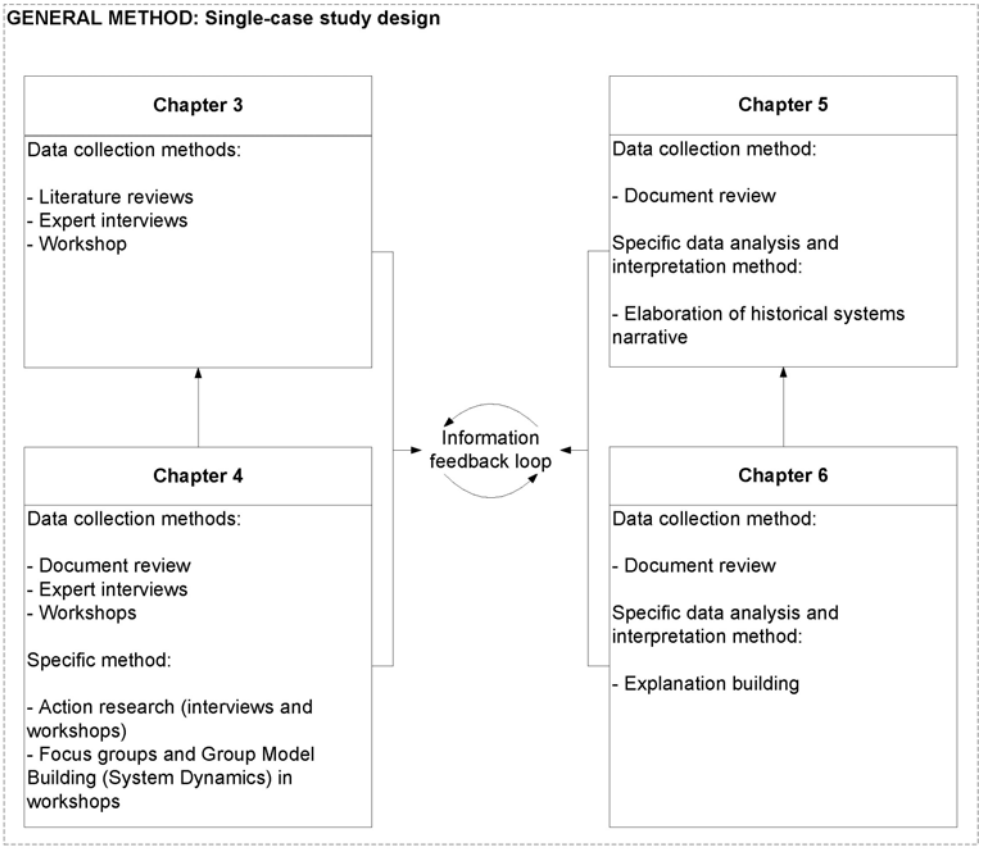

Figure 10. Overview of methods used in this thesis

Next chapter (Chapter 3) describes the research carried out in British Columbia aimed at learning about the Canadian experience on adaptive management. The lessons learnt in that research served to support the action-research program developed in the Doñana region (Chapter 4).

Chapter 3. Learning from the Canadian experience on adaptive management

3.1. Introduction

To understand the research presented in this chapter[18], the project within which it was framed must be briefly introduced. It was a long-term research initiative termed TRANSAM (*Trans*fer of *A*daptive *M*anagement; see Méndez et al. 2010), launched in 2007 and is currently ongoing at the Spatial Ecology Group of the Doñana Biological Station. The general aim of TRANSAM is to investigate the causes of the limited transfer of adaptive management from Canada to the European Union (EU). Adaptive management constitutes one of the most promising approaches to overcome the current limitations of traditional, command-and-control management and policy making of natural resources and nature conservation, at both the operational and decision-making levels. It is an approach initially conceived and developed by C.J. Walters, R. Hilborn, C.S. Holling and associates at the University of British Columbia (Vancouver, Canada) and the International Institute for Applied Systems Analysis (Vienna, Austria), during the 1970s and the 1980s (Walters and Hilborn 1976, Walters and Hilborn 1978, Holling 1978, Walters 1986). The aim was to create a robust tool for the management of natural resources while keeping a continuous interaction among stakeholders. For the purpose of clarity, this thesis uses the working definition and basic features of adaptive management included in Box 3. Since its inception, adaptive management has been applied to a wide range of natural resources management and nature conservation problems worldwide, mainly in Canada, USA, Australia, New Zealand and, more recently, in some countries of the European Union (see for example ESSA 1982, MacDonald et al. 1997, Bouris 1998, Marmorek et al. 2006, Santamaría et al. 2006, as well as the websites of the NeWater Project 2009 and the Stockholm Resilience Centre

[18] The research described in this chapter has been published in: Méndez, P.F., Santamaría, L., Amezaga, J.M. and Hearns, G., 2010. Adaptive strategies for natural resources and ecosystems management in Canada. Opportunities and constraints for implementation in Europe. Report prepared for the International Council for Canadian Studies. [Online] Available at: https://dl.dropboxusercontent.com/u/65349011/Mendezetal_2010.pdf

2009). This has provided an accumulating body of knowledge that present it as a valid alternative to command-and-control, which may be considered instrumental for achieving sustainable resource use. However, after 40 years of development and (often) successful implementation in Canada, until the current decade it received limited attention in Europe – and even less in Southern Europe. The limited implementation of adaptive management in Europe contrast vividly with its widespread use in the Anglo-Saxon world (Canada, USA, Australia and New Zealand), bringing up questions on whether there are specific institutional, technical, scientific or even cultural traits of the societies across the Atlantic divide that prevent the dissemination of these seminal ideas.

Box 3. Working definition and basic features of adaptive management used in this research

Adaptive management is a cyclic, iterative strategy at the interface among science, management and policy, designed for learning about the performance of different policy decisions, in the operational management of natural resource systems and ecosystems.

Its formal features are:

1. the explicit acknowledgement of
    a. the existing, coupled socio-ecosystem, its complexity and related uncertainties;
    b. the need for an upfront definition of problems, and the questioning of social and ecological causal, spatiotemporal interrelationships and feedbacks;
    c. the need for the clear establishment of feasible policy and management objectives and indicators;
2. the systematic formulation of (alternate) hypotheses about socio-ecosystem functioning and policy performance, the consideration of alternatives at many policy and management levels and scales, and the design of robust experimental settings and sound monitoring programs;
3. the systematisation (analysis and organization) of stakeholder involvement;
4. the development and interfacing of models of the functioning of the socio-ecosystems for collectively learning about uncertainties, assumptions and predictions of causes and effects, and judging how well alternatives perform towards the achievement of objectives;
5. the flow of information and the transfer of trans-disciplinary knowledge, expertise and experience among individual actors and organizations;
6. the analysis and evaluation of outcomes in consideration of the established goals, and the assessment of the overall process and the necessity of restart.

Source: Based on Holling (1978), Walters (1986), Lee (1993), Gunderson et al. (1995), Walters (1997), Salafsky et al. (2001), Jacobson (2003), Murray and Marmorek (2004), Walkerden (2005), Gregory et al. (2006), Marmorek et al. (2006), Pahl-Wostl (2007), Bunnell (2008).

As part of the normative component of the research presented in this thesis, a more specific objective of the TRANSAM project was to inform and provide support for the action-research program implemented in the Doñana Nature Reserve. The particular focus was on identifying the institutional opportunities and constraints for adaptive management, by learning from a number of cases from British Columbia (Canada) applying that approach to natural resources and ecosystems management. This chapter reports the methods and results of the first phase of the TRANSAM project, designed for accomplishing the following objectives:

- To document the Canadian experience with adaptive management, with an emphasis on British Columbia.
- To assess a series of case studies in which particular institutional developments allowed for the implementation of adaptive management initiatives for natural resources management and nature conservation.
- To develop a deep understanding of both the concept and the associated process of stakeholder involvement, in order to inform and provide support for the action-research program in the Doñana region (Chapter 4).

3.2. Methods

I used three types of methods: literature reviews, expert interviews and workshop. First, through extensive literature reviews, I undertook: (1) a historical analysis of the Canadian institutional framework for natural resources management, assessing the situation of adaptive management in the context of that framework; (2) the selection of several initiatives and projects applying the adaptive management of natural resources management and nature conservation in British Columbia. The levels of enquiry of the Institutional Analysis and Development framework were broadly applied to the historical analysis of the Canadian institutional framework for natural resources management, in order to keep coherence with and transfer of lessons to the action-research program and the institutional analysis of the thesis.

Second, I identified experts from the selected projects and initiatives on the basis on two types of criteria (see Table 4), and interviewed them. The key idea that guided this part of the work was that, since adaptive management has undergone more than four decades

of development in British Columbia, the identified experts had a sound understanding of the existing institutional opportunities and constraints for its operational implementation in their fields of application. Interviews were designed as semi-structured and open-ended, in order to allow for additional questions, as well as for the free and profound expression of the interviewees ideas. Nevertheless, the interviews were guided by primary themes to keep the focus on those most relevant for the research (see Appendix 1 for the question guides). The main aims of the interviews were three: (1) to build trust with the interviewed experts; (2) to pave the way towards the preparation of a workshop aimed at learning from the experience of the participants on adaptive management in a collaborative environment (see below); (3) to gather information, and to produce and assess the experts' accounts on adaptive management[19]. All the interviews were preceded by a brief introduction to the TRANSAM project and to the action-research program being undertaken in Doñana. The interviewees quoted in this research signed informed consents in retrospective (see its format and content in Appendix 2).

Table 4. Criteria used for the selection and grouping of experts

Historical criteria
A. He/She has historically contributed to the development of the theory and/or practice of adaptive management (since its inception in the 1970s-1980s)
B. She/He is currently contributing to the development of the theory and/or practice of adaptive management
C. He/She has actively participated in the historical institutional process lived in the Clayoquot Sound Biosphere Reserve[a]
Qualitative criteria
D. She/He possesses relevant information about the identified adaptive management project or initiative
E. He/She possesses relevant information about the recent institutional development of the Clayoquot Sound Biosphere Reserve.
F. She/He is visible and accessible through information gathered from the web
G. He/She is visible and accessible through our Canadian project's partners or through other interviewees

[a] The Clayoquot Sound Biosphere Reserve was the flagship case of the TRANSAM project in British Columbia. In this thesis, it is reported as one more case on adaptive management.

[19] The information gathered in the interviews is currently being used in a research aimed at developing a series of fine-grained benchmarks against which to compare adaptive management initiatives. The results of that research will be presented elsewhere.

Finally, I organised an adaptive management workshop involving a group of 10 key experts, with the support of the research team of the TRANSAM project. The participants were selected from the most relevant projects identified along the interviews. The workshop was designed as a half-day interactive activity for participants, aimed at providing them with the opportunity to engage in the discussion and exchange of ideas on the topic of interest. Sessions were organised around brief keynote lectures, followed by discussion at the end of each session. The general questions that we aimed to answer at the workshop were:

1. Theory: how has theory been developed and what does it say? Practice: how has it been implemented and what are the results?
2. What is the role of science-management-policy interfaces for the implementation of successful adaptive management programs?
3. Which are the main barriers and opportunities for adaptive management implementation, from the institutional, legislative and technical perspectives? Which factors determine the extent of stakeholder involvement, and what is their role?
4. Closing the adaptive management loop: how does our experience and practice influence our theory –which in turn influences practice? ('Applying adaptive management to the academic theory of adaptive management') Does practice support theory? Does theory provide with guidelines and principles for successful adaptive management implementation?

In line with the main objectives of the project, the workshop focused on four issues:

1. Reviewing the Canadian experience with adaptive management, with an emphasis on British Columbia.
2. Evaluating the relative roles of science and stakeholder involvement in the processes of policy making in Canada, particularly at the first stages of adaptive management programs.
3. Identifying the major institutional opportunities and constraints for the adaptive management of natural resources (e.g., water, timber, fisheries and minerals) and nature conservation (e.g., nature reserves, endangered species, ecological restoration), in British Columbia – and, more generally, in Canada.

4. Discussing the relationships and feedbacks between the practical applications and theoretical developments of innovative strategies based on adaptive management.

The workshop was divided in three sessions (for further details on the organisation of the workshop see Méndez et al. 2010):

Session 1: Management experiences, practice and outcomes.
Session 2: Science-management-policy interfaces and stakeholder involvement.
Session 3: Closing the adaptive management cycle – learning from practice.

3.3. Results

3.3.1. The Canadian framework for natural resources management

Canada's socioeconomic development has been historically based in the great availability of natural resources (e.g., fisheries, timber and minerals). From pre-Columbian times, when aboriginal people already managed them (Notzke 1994), natural resources provide Canadians with most of their cultural heritage and high living standards. For example, forests constitute approximately half of Canada's land base (921 million ha, of which 418 M ha are considered commercial forest and 119 M ha are used for timber production) (Hessing et al. 2005). Though plagued with recurrent crises, marine fisheries are still abundant and constitute an important economic sector in Canada, contributing significantly to the value-added of commodity-producing industries, the employment and the GDP of several provinces (e.g., Newfoundland, Nova Scotia, Prince Edward Island) (Parsons 1993, Department of Fisheries and Oceans 2008). However, governmental resource policies (at both federal and provincial level) are largely constrained by the nature and dynamics of export activities and the integration of the Canadian economy in the international markets (staples-dependent economy) (Hessing et al. 2005).

The institutional framework for natural resources management and nature conservation, and the functions of the State in both sectors has been socially and politically conflictive during the last century at many levels – leading to several power struggles at the constitutional level between the federal and provincial governments, which usually

ended in instrumentalist approaches for conflict resolution (Ayling and Kelly 1997, Buckles 1998). At the constitutional level, the Canadian division of authority has provided (and still provides) provinces with fundamental powers over natural resources, with the exception of fisheries (British North America Act of 1867, hereafter BNA; Constitution Act of 1982) (Litfin 2000). The constitutional order determines governmental responsibilities, policy-making and legislative powers (e.g., entitled decision-makers), and decision making abilities within governmental organisational structures. It also guarantees existing aboriginal and treaty rights, all of which was determined by colonial practices and the BNA (Webber 1994, Hessing et al. 2005). The first constitutional act (BNA) was largely influenced by timber trade actors, a fact that largely established the basis for a resource-based economy that lasted until today (Natural Resources Canada 2008).

From the second half of the 19th century up to mid-20th century, resource extraction and conservation (mainly timber) was moderated through the development of new administrative arrangements at many (constitutional, collective-choice and operational) levels (e.g., regulations, regulatory agencies, provisions, long-term tenures, engineering commissions). The increasing amount of technological and industrial developments made provincial governments aware of the uncertain character of long-term resource supply (Hessing et al. 2005). During this era a system for nature conservation (e.g., national parks, forest reserves) was created "in order to preserve some areas from destruction" (Hessing et al. 2005). Prior to 1867, when the Constitution Act was passed, environmental quality needs were not explicitly considered (Rankin 1993). Before World War II, environmental functions like nature conservation (e.g., parks services) were largely entrusted to provincial ministries, but were "minimal, fragmented, and framed primarily in terms of human economic and organisational requirements" (Hessing et al. 2005).

From 1950 onwards, conservation efforts by both federal (e.g., regional development incentives, Forestry Act of 1949) and provincial (e.g., forests and mineral reserves) governments continued in the same atmosphere of strong provincial opposition to federal regulatory initiatives, which accelerated dramatically the complexity and fragmentation of environmental provisions, regulations and administrative structures between the two levels (Hessing et al. 2005). This ultimately led to a vertical transfer of

powers from federal to provincial governments, but to a horizontal transfer of functions between different organisational structures with overlapping jurisdictions at different levels (e.g., federal and provincial agencies and departments) (Hessing et al. 2005).

Currently, the Canadian environmental legislation (e.g., wilderness and species protection) and the administrative structures for its enforcement, which partially stem from resource policies, are very complex – and a reflection of the historical federal-provincial struggle. With the creation of Environment Canada, in 1985, responsibilities over policy formation for environmental enhancement, renewable resource management and conservation (e.g., wildlife), and pollution prevention, became shared by the federal and the provincial governments - and showed substantial overlaps (Department of the Environment Act 1985, Canadian Environmental Protection Act 1999). An Environmental Protection Service was created to coordinate the activities of the Departments of Environment previously established within the provinces, which gave rise to regulatory functions and punitive sanctions, rather than resource management structures (Macdonald 1991, Brown 1992). Yet "the legacy of structural fragmentation in jurisdiction and regulatory standards continues (nowadays) to make resource and environmental administration a complex and difficult process" (Hessing et al. 2005).

The enactment of the Constitutional Act of 1982 involved two facts of great significance for the Canadian processes of policy formation: it strengthened the federal-provincial division of powers and jurisdiction, and gave certain powers to First Nations. In particular, Section 92 of the Act provides provincial government with legislative jurisdiction over natural resources (e.g., forestry and mining), with the important exception of fisheries (seacoast and inland) and resources affected by international affairs or treaties (e.g., trans-boundary parks), which are under the jurisdiction of the federal government (Section 91.12). Section 35 recognizes and affirms existing aboriginal and treaty rights, and gives jurisdiction to First Nations.

> *"Such division of powers has led to a very complex, legalistic structure for the management of some resources. For example, the federal government has legislative jurisdiction over certain species of anadromous species of fish (e.g., Pacific species of salmon – Sockeye, Chinook, Coho), and has administratively delegated authority back to the provincial government for the management of the*

> *so-called 'provincial species of fish' (e.g., rainbow trout, steelhead). However, despite such administrative transfer of powers, the latter remains within the federal sphere of jurisdiction. This adds a certain dynamic tension over legislative jurisdiction affairs among the federal, provincial and First Nations governments, because legislative jurisdiction means certain control power over resources (though ownership jurisdiction is needed to get overall control)."* (Richard Kyle Paisley, extract from interview).

At the end of the 1980s and during the 1990s, the 'sustainability paradigm' (Hessing et al. 2005) saturated the Canadian resource-policy agendas (Forest Resource Development Agreements 1985-1990, National Forest Strategies 1992, 1998). After long consultation processes by the federal government, in 1984, subsequent National Forest Strategies (1992, 1998, 2003-2008) have evolved from *ad hoc*, collective-choice institutions (e.g., inter-ministerial meetings) to soundly constituted policy forums. These procedures reflect a true effort to broad public participation in drafting policy strategies, but they also restrict the constitutional power of the federal government, vesting it to the provinces (Howlett 1989). Nowadays, the institutional, federal-provincial framework for natural resource management and nature conservation remains fragmented (provincial and municipal governments are even acquiring more responsibilities), though in the forest sector "the major forest-owning provinces exhibited a pattern of policy convergence over the second half of the twentieth century" (Hessing et al. 2005).

3.3.2. Expert interviews

The output of the methods described above was an inventory (summarised in Tables 5 and 6) of 31 initiatives and projects that: (1) apply the principles of adaptive management for natural resources management and nature conservation, or addressed conceptual challenges posed by its application – mainly at British Columbia, but also elsewhere in Canada and USA, or even worldwide; or (2) developed new institutions (e.g., scientific panels, decision boards) in the recent past. Selected projects and initiatives included whole projects fully committed to adaptive management, others that prescribed adaptive management as a best practice and yet others that simply focused on its theoretical development. From them, I identified 31 experts (see Table 5), from which I succeeded to interview 29.

Table 5. Selected adaptive management projects and initiatives

Project/initiative	Project description	Organization	Sector type/Class criteria	Identified actor	Selection criteria	Position	Interview?
Enabling Adaptive Forest Management	Factors needed for successful AM in the forest sector	ESSA Technologies Ltd.	Private/USA	David Marmorek	A, B D, F	President	Yes
BC Coast Forest Strategy	Balancing ecological, social and economic goals for managing industrial logging	Western Forest Products Inc.	Private/BC	William J. Beese	A, B, C D, E, F	Forest Ecologist	Yes
Ecosystem Based Management Working Group	Alternative ways to meet ecosystem management objectives	Compass Resource Management Ltd.	Private/BC	Lee Failing	B D, G	Partner	Yes
Jumbo Glacier Alpine Resort	Identifying and mitigating impacts on grizzly bear populations	Compass Resource Management Ltd.	Private/BC	Michael Harstone	B D, G	Partner	No
Grand Canyon Ecosystem Model	Define and prioritise research programs and experimental monitoring design	Ecometric Research Inc.	Private/USA	Josh Korman	B D, G	Systems Ecologist	Yes
Community-Based Natural Resource Management Program	Adaptive policy frameworks and community-based resource management in Asian countries	Adaptive Resource Management Ltd.	Private/Worldwide	Stephen Tyler	B D, G	President	Yes
Red River Basin Adaptive Management Simulation Model	Explore natural, economic and social dynamics, and alternative policies with stakeholders and decision makers	Lookfar Solutions Inc.	Private/USA	Tim Webb	B, C D, E, G	President	Yes
Clayoquot Sound Monitoring and Indicator Strategy	Indicators and stressors for monitoring social, economic and ecosystem productivity in Clayoquot Sound	Clayoquot Forest Management Ltd.	Private/CS	Warren Warttig	B, C D, E, G	Planning Biologist	Yes

Table 5. Selected adaptive management projects and initiatives

Project/initiative	Project description	Organization	Sector type/Class criteria	Identified actor	Selection criteria	Position	Interview?
Adaptive Environmental Assessment and Management	*"Due to high uncertainty in our behaviour models of resource management systems, all management actions are properly described as experiments with uncertain outcomes… rather than implementing 'best management practices', resource managers are actually relying on a 'working hypothesis' — whether they realise it or not"* (Holling 1978)	Department of Zoology, University of Florida	Scientific-technical/ Conceptual	C. S. Holling	A, B D, F	Eminent Scholar, Arthur R. Marshall Jr. Chair in Ecological Sciences	Yes
Sustainable Forest Practices in Clayoquot Sound	Develop world-class standards for sustainable forest management combining traditional and scientific knowledge	Scientific Panel for Sustainable Forest Practices in Clayoquot Sound	Scientific-technical/ CS	Frederick L. Bunnell	A, B, C D, E, F	Panel Co-Chair (Honorary Professor at UBC)	Yes
Weyerhaeuser's Forest Project – Monitoring Biological Indicators During the AM Program	Effectiveness of retention systems and zoning in maintaining forest attributes necessary to sustain biological richness and essential ecosystem functions	Forest Sciences Department, Forestry Faculty, University of British Columbia	Scientific-technical/ BC	Laurie Kremsater	B, C D, E, G	Forest Biologists	No
Reserve Design as a Tool to Conserve Species, Communities and Ecosystems	Policies that anticipate 'failure' and learning from failures, as basic components of planning	Forest Sciences Department, Forestry Faculty, University of British Columbia	Scientific-technical/ Conceptual	Peter Arcese	B D, F	Professor (Co-Director – Centre for Applied Conservation Research)	Yes
Rivers Inlet Project	Research on causes of declines in sockeye salmon populations –sound monitoring programs, mathematical hydrodynamic modelling and innovative statistical techniques	Department of Statistics and Actuarial Science, Simon Fraser University	Scientific-technical/ BC	Rick Routledge	A, B D, F	Professor in Statistics	Yes

Table 5. Selected adaptive management projects and initiatives

Project/initiative	Project description	Organization	Sector type/Class criteria	Identified actor	Selection criteria	Position	Interview?
CALFED Bay-Delta Program –Science Program	Improve California's water supply and the ecological health of the San Francisco Bay/Sacramento-San Joaquin River Delta –AM within CALFED agencies	CALFED Bay-Delta Program	Scientific-technical/ USA	Mike Healey	A, B D, G	Lead Scientist (2006-2008)	Yes
Clayoquot Alliance for Research, Education and Training	Research on specific issues and needs that exist among Clayoquot Sound communities, academic community and institutional borderlands	Department of Public Administration, University of Victoria	Scientific-technical/ CS	Rod Dobell	B, C D, E, F	Principal Investigator	Yes
Strategic Planning in Arctic Resource Communities	Understand how climate change will affect Nunavut communities – implementation of AM programs	Institute for Resources, Environment and Sustainability IRES, University of British Columbia	Scientific-technical/ Canada	Michelle Boyle	B D, G	PhD	Yes
Computer Models for Adaptive Forest Management	Tools to help managers in achieving their objectives of sustainable forest management in an adaptive framework	Forest Sciences Department, Forestry Faculty, University of British Columbia	Scientific-technical/ Conceptual	Juan Blanco	B D, E, G	Postdoctoral Research Fellow	Yes
Forests and Oceans for the Future	Incorporate core community values and knowledge in local sustainable forests and natural resource management	Department of Anthropology, University of British Columbia	Scientific-technical/ BC	Charles R. Menzies	C E, G	Associate Professor of Anthropology	Yes
International Watercourses/River Basins Including Law, Negotiation, Conflict Resolution and Simulation Training Exercises	Study of international water law and conflict resolution	Faculty of Law, University of British Columbia	Scientific-technical/ Conceptual	Richard Kyle Paisley	B E, G	Director, Dr. Andrew R. Thompson Natural Resources Law Program	Yes
BC Forest Service Adaptive Management Initiative	Explore how AM can be applied to help continuously improve forestry practices in BC	BC Forest Service, Forest Practices Branch, Ministry of Forests and Range	Government/BC	Brian Nyberg	A, B D, F	Manager	Yes

Table 5. Selected adaptive management projects and initiatives

Project/initiative	Project description	Organization	Sector type/Class criteria	Identified actor	Selection criteria	Position	Interview?
Forest and Range Evaluation Program (Forest for Tomorrow)	Science-based information for decision-making and continuous improvement of forest and range practices, policies and legislation in BC	BC Forest Service, Forest Practices Branch, Ministry of Forests and Range	Government/BC	Alanya Smith	B D, G	Effectiveness Evaluations Coordinator	Yes
The Watershed Evaluation Tool (WET)	Study and rank large watersheds, using indicators to evaluate each watershed's inherent physical sensitivity	Ecosystems Branch, BC Ministry of Environment/University of British Columbia	Government/BC	Eric Parkinson	B D, G	Officer (MOE)/ Senior Fisheries Scientist (UBC)	Yes
Adaptive Management in Water Use Plans	Find a better balance between competing uses of water in BC –active AM, or experimentation with operational changes	BC Hydro (Crown Corporation)	Government/BC	Paul Higgins	B D, G	Senior Research Biologist	Yes
Strategic Land and Resource Plans in BC	Provide increased certainty and form the foundation for balanced solutions that meet economic, environmental, and social requirements throughout BC	Integrated Land Management Bureau, Ministry of Agriculture and Lands	Government/BC	Brian Retzer	C E, G	Planning Officer	Yes
Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas	Make consistent, credible and informed decisions regarding the management of issues of common concern to parks and protected areas agencies in Canada and internationally	Pacific Rim National Park/Parks Canada	Government/Canada	Yuri Zharikov	B, C D, E, F	Park Monitoring Ecologist	Yes
Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas	*Ditto*	Pacific Rim National Park/Parks Canada	Government/Canada	Ed Paleczny	B, C D, E, F	Manager of Resource Conservation	Yes
Friends of Clayoquot Sound	Create of a conservation-based society, with a corresponding conservation-based economy	Friends of Clayoquot Sound (Commnunity-based organization)	NGO/CS	Maryjka Michajlowycz	C E, F	Forest Watch	Yes

Table 5. Selected adaptive management projects and initiatives

Project/initiative	Project description	Organization	Sector type/Class criteria	Identified actor	Selection criteria	Position	Interview?
Clayoquot Sound Biosphere Reserve	Nuu-chah-nulth First Nations philosophy 'Hishuk ish ts'awalk', or 'everything is one' –to promote truly sustainable local communities and economies	UNESCO	NGO/CS	Rebecca Vines	C E, F	Community Coordinator	Yes
Conservation Economy	Conservation economy –promote innovation and provide services for communities, First Nations and enterprises to green and grow their local economies	Ecotrust Canada (non-profit)	Private/Canada	Brenda Reid-Kuecks	C E, G	Director of Community Programs	Yes
Clayoquot Field Station	Transformative, experiential and interdisciplinary learning to solve problems on a local, national and global scale	Tofino Botanical Gardens Foundation (non-profit)	Private/CS	George Patterson	C E, G	Director	Yes
Tla-o-qui-aht Nation Building Strategy: ha'wiih and ma'uas (chiefs and houses)	Consult the oral historians of the Tla-o-qui-aht First Nation, and document their knowledge pertaining to Ha'wiih, the caretakers and controllers of the haahuulthii (Nation's natural and cultural values) and responsible of many aspects of the Nation's governance	Tla-o-qui-aht First Nation/Nuu-chah-nulth Tribal Council	First Nations/CS	Sayachapis (Marc) Masso	C E, G	Treaty Negotiator	Yes

Experts belonged to different management and research organizations, including private (profit and non-profit) and Crown corporations, universities, provincial and federal departments and agencies, non-government organizations, and a treaty negotiator from the Tla-o-qui-aht First Nation. 24 interviews were made face-to-face and 4 by telephone, with an average interview duration of approximately one hour. In most cases (25), interviews were recorded and text transcripts were produced and stored. Those not recorded were due to logistical reasons. All were experts with proved long-term experience in the field of adaptive management both in the development of its theoretical aspects and in its operational practice. Some interviewees were *ex-situ* senior experts from finished projects, and other were *in-situ* experts from ongoing projects. In all cases, priority was given to experts from the operational levels, i.e. executives, managers, researchers, technicians and environmentalists on the ground. The information gathered in the interviews was enriched with other information sources and literature provided by the interviewees.

Table 6. Expert interviews, organised by sector type and class criteria

			Sector type					
Class criteria			**Scientific-technical**	**Private**	**Government**	**First Nations**	**NGO**	**Totals**
Project geographic location	Canada	British Columbia	4	4	5	1	2	**16**
		Elsewhere	1	1	2[a]	-	-	**4**
	Elsewhere in USA		1	3	-	-	-	**4**
	Worldwide		-	1[b]	-	-	-	**1**
Conceptual			4	-	-	-	-	**4**
		Totals	**10**	**9**	**7**	**1**	**2**	**29**

[a] Federal Government (Parks Canada)

[b] Community-Based Natural Resource Management Program – adaptive policy frameworks and community-based resource management in Asian countries

3.3.3. Report on the case studies

This section begins with a report of the Clayoquot Sound Biosphere Reserve case, which was assessed using information from the interviews. The remainder of the section reports the case studies presented at the adaptive management workshop (University of British Columbia, 5th December 2007), namely: the Forest Project, the Jumbo Glacier Alpine Resort and the Water Use Planning Process in British Columbia (BC for the remainder of this chapter). All experts chosen for the workshop had a fair amount of experience in adaptive management. At the time, they were participating (or had participated recently) in important projects or initiatives implementing adaptive management (AM for the remainder of this chapter) programs for natural resources management and nature conservation, often dealing with complex social-ecological problems. I include direct quotes from the workshop in boxes interspersed with the main text.

3.3.3.1. Institutional developments in the Clayoquot Sound Biosphere Reserve

The Clayoquot Sound was selected for investigation because it constitutes a paradigmatic case of specific institutional developments in the fields of natural resources management and nature conservation that, along the 1990s, led to novel socio-political and economic agendas promoting (Bunnell et al. 1994, Pinkerton 1999, Dobell 2001, Dobell 2002):

- Sound principles for public participation, especially of First Nations, as well as the non-aboriginal population and environmentalists (e.g., multi-stakeholder negotiation, community-centred participatory processes).
- The use of alternative or innovative approaches for the planning and practice of natural resources management and nature conservation, particularly those incorporating social-ecological complexities and uncertainties into policy and decision making (e.g., AM).

The Clayoquot Sound Biosphere Reserve is located on the west side of Vancouver Island, off the coast of BC. It is home to the Ahousaht, Tla-o-qui-aht, Hesquiaht,

Toquaht and Ucluelet, five groups of a broader aboriginal community: the Nuu-chah-nulth First Nations (aprox. 50% of the total population) (Dobell 2001). It comprises 265,000 ha of land (8% of the island) and 85,000 ha of ocean mainly consisting of narrow and large inlets (sounds) to which rivers and lakes empty their waters (Friends of Clayoquot Sound 2008, UNESCO 2008). The region is comprised of a diverse range of ecosystems, being the most representative the coastal temperate rainforest (93% of the land base). Coastal temperate rainforest is one of the rarest and most diverse ecosystems of the world, and has been subject to varying types and degrees of intensive industrial activity during the last decades – mostly logging (Dobell 2001, Bunnell 2008). Since 1970, several areas within the region have been protected by the federal and regional governments (e.g., Long Beach unit of the Pacific Rim National Park, Flores Island Provincial Park).

During the 1990s, the Clayoquot Sound faced several structural adjustments and social conflicts over the region's development. These conflicts were characterised by the emergence of contrasting approaches to natural resources management and nature conservation, stemming from differences in values and belief systems, and economic interests. The more characteristic was the industrial-logging vs. protection-for-conservation value clash, stemming from the view of forests as marketable ecosystems or as ecosystems endowed with spiritual and aesthetic values (Dobell 2001). These tensions were slowly resolved through a transition towards different institutional structures (Magnusson and Shaw 2003, Dobell 2001) and fundamental transformations in "attitudes, patterns of communication, and trust, all of which led to a willingness to partner, learn, and work together" (Pinkerton 1999).

The process of change outlined above interacted profoundly, and probably also fostered, First Nations´ historical claims for co-management treaties and land-rights devolution processes – since First Nations land had not been transferred to Canadian governments by any treaty. Many aboriginal management systems (e.g., "Nuu-chah-nulth *ha health"* or "Chiefs Territory") entrust chiefs with the right and responsibility to protect the lands and waters in their territory and preserve the resources for future generations. According to both First Nations members and some academics, these management systems constituted more reliable approaches to preservation than private property ownership (Shaw 2001). The conflicts faced the BC's provincial government and courts with the

contradictory obligation of ensuring compliance with both the constitutional right of local (aboriginal and non-aboriginal) communities for civil disobedience against (non-restrained) logging, and the logging contracts between governmental agencies and industrial corporations (Rojas 1995). The conflict started to affect the international reputation of Canadian logging practices, thus affecting negatively the demands for exported timber and wood products.

Institutional innovation reached a tipping point in 1993, when the Government of BC created the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (the Panel hereafter) (Dobell 2001, Rojas et al. 2002, Bunnell 2008). The Panel was conceived as an independent body aimed at the development of world-class standards for sustainable forest management (e.g., long-term productivity and natural diversity of the Clayoquot region) by combining traditional ('lived experience') and science-based ecological knowledge (scientific data). It included experts from the Nuu-chah-nulth communities along with academics from different research organizations (Sit and Taylor 1998, Dobell 2001).

To achieve its main goal, the Panel produced in 1994 a first report addressing the framework and guiding principles for reviewing historical standards and developing new ones. The report recommended the use of AM strategies for improving both public and private forest planning and management practices, with specific targets such as responding to new knowledge and experience, as well as to unforeseen natural and human-induced environmental changes. It also emphasised the need for triggering social learning (Dobell 2001), by actively involving local actors (e.g., affected local communities, First Nations, industrial stakeholders) in planning and management processes (Bunnell et al. 1994).

Table 7 presents a global assessment of thirteen key themes that the interviewees consistently identified as important issues for the successful implementation of AM strategies. These themes are presented as positive statements (first column), accompanied by the qualitative values that the interviewed experts gave to the statements during their accounts, separately for the periods before and after 1993 (second and third columns). All the interviewed experts referred to 1993 as the year when the socio-political system of the Clayoquot Sound changed to a more forward

looking, innovative regime, setting the pace of future institutional innovations on the ground. I paid particular attention to those themes repeatedly addressed by most interviewees, and classified them from the perspective of AM, as: institutional "general opportunity", "general constraint" or "case-dependent opportunity/constraint".

Table 7. Key themes identified by the interviewees as important issues for the successful implementation of AM strategies.

Statement	Before 1993	After 1993
Presence of AM pilot projects on the ground (public and private)	Constraint (no presence)	Opportunity (presence)
Use of operative methodologies and procedures for stakeholder involvement	Constraint (scarce use)	Opportunity (broad use)
Commitment for long-term monitoring of implemented measures	Constraint (low commitment)	Case-dependent
Fear to uncertainty within management agencies	Constraint (high)	Case-dependent
Existing organisational capacity and structures	Case-dependent	Opportunity (growing)
Willingness of local communities	Case-dependent	Case-dependent
Existing political (i.e. from-the-top) support	Case-dependent	Opportunity (increasing)
Strength of (socioeconomic) sectoral interests	Constraint (very strong)	Opportunity (less strong)
Power of command and control strategies as exclusive options	Constraint (very powerful)	Opportunity (less powerful)
Existing policy and legal structures	Constraint (non-existing)	Case-dependent
Institutional inertia (rules reproduction)	Constraint (high persistence)	Case-dependent
Extent of inter-agency coordination	Constraint (low extent)	Constraint (low extent)
Persistence of multi-level conflicts	Constraint (high persistence)	Constraint (high persistence)

3.3.3.2. The Forest Project

The assessment of the Forest Project is based on its description by three key experts at the three sessions of the AM workshop. Therefore, each expert covered a different aspect of AM according to the objectives of each session.

The first presentation, given by Bill Beese at Session 1 (Western Forest Products Inc.), concerned the test of new strategies for the management of BC's coastal forests, by the

different companies that he has worked for (MacMillan Bloedel, Weyerhaeuser and Western Forest Products), under the umbrella title of 'The Coast Forest Strategy'. The first initiative, called the 'Forest Project', was announced by MacMillan Bloedel in 1998 as a strategic response to increasing demand, in the global marketplace, for wood from sustainably managed forests. It extended over an area of about 1.1 million ha of forested land on the coastal mainland and larger islands of BC. MacMillan Bloedel was consecutively acquired by Weyerhaeuser and Western Forest Products, both of which adopted the key strategic elements of the Forest Project. Basically, this project sought to address public concerns regarding clearcutting, old growth forests and biological diversity. Its main goals were to operate a safe and profitable business, to maintain public and marketplace approval (social license), and to sustain biological diversity.

We want to sustain healthy and productive forests and conserve biodiversity on our tenures, which are primarily public land that we manage under long-term leases with the government.

We have been doing retention at the stand level, moving out of clear-cutting toward other approaches that leave a variety of structure behind, more similar to what nature would do.

By 2007, Western Forest Products was attempting to accomplish this goal using a three-tiered approach that included: (1) ecosystem representation (having a certain proportion of all ecosystems represented in reserves on the land base), (2) the maintenance of structure at the stand level, and (3) the maintenance of species diversity. The first approach was fulfilled primarily through a system of landscape-level reserves throughout the BC province, including riparian reserves, sensitive terrain, wildlife habitat areas, and old-growth management areas). The second approach (to maintain structure at the stand level) combined two measures: more old growth was reserved from harvest through a system of stewardship zones, and 'variable retention' (VR)[20] was implemented for most harvesting, instead of clearcutting. The third approach was fulfilled by the development

[20] The 'retention system' is an approach for the sustainable management of forest ecosystems at the stand level. It operates by retaining individual or groups of trees, in order to maintain structural diversity over cutblock areas. 'Variable retention' operates at the landscape level, utilising a broader spectrum of retention strategies, in combination with conventional silvicultural systems (e.g., uniform shelterwood with group reserves). By retaining part of the original forest after harvesting, variable retention focuses on the role of structural complexity in maintaining forest ecosystem function and biodiversity, hence a wider variety of forest values, such as wildlife habitat and aesthetics. The term variable retention was first introduced in British Columbia by the Clayoquot Scientific Panel in 1995 (for further details see Franklin et al. 1997).

and application of species diversity indicators, which produced a species accounting system that covered the needs of all the different forest species.

VR was the core approach of the Forest Project. This approach was being used in a framework of eco-sections (broad areas of similar geography, topography and climate), which helped to set new management standards across the company. VR represented a new management strategy to harvesting and silviculture based on differential long-term retention of trees (different long-term levels of leave-tree retention – types, amounts and patterns), introduced through the design of AM experiments. This strategy allowed for the adaptation of traditional silvicultural systems and met social demands for different alternatives to clearcutting. The implementation of AM programs focused on VR, included the establishment of several experimental areas for comparing its biological and economic impacts, as well as the independent monitoring of structural attributes, single species, forest growth and yield, wind-throw and small streams – in random samples of cutblocks subjected to different VR regimes.

Communication among different working groups is necessary to ensure that scientific findings provide feedback to management action, and close the loop in the AM process.

For that purpose, an AM Working Group and a VR Working Group were formed. The first group (comprised primarily of researchers, including academics, consultants, employees, representatives of companies with adjacent tenure, and government representatives) developed a framework for action, methodology and pilot protocols for effectiveness monitoring (monitoring framework documents, indicators and experimental block comparisons). The VR Working Group was composed of practitioners – those who had to implement the new planning and practices. Early discussions in the VR Working Group focused on how to make the new practices work. With time and demonstrated ability to make new practices work, discussions focused increasingly on conflicts between economic return and sustaining biodiversity –"*illustrating that a wicked problem remains wicked"* (Bunnell, quote from the workshop). While the design of the broad elements of the new approach (including monitoring protocols) resided in the AM Working Group, the innovation and the practicality of making new practices work resided primarily in the VR Working Group. The development of objectives and indicators made it possible to answer specific questions, set up certain actions and monitor well defined processes. For

example, Beese focused on one them: wind damage – *"how much wind damage (wind-throw and breakage) are we getting just because of the edge of the cut-block, the edges of large patches and the edges of small groups that we have left?"* (Beese, quote from the workshop).

We had a decision structure within the company, with some organisational structures designed to make the whole feedback loop happen.

At Session 1 of the workshop, Bill Beese presented data for a 3-5 year period showing that the retention system within the different blocks wasn't the primary problem with wind damage, and that significant challenges remained with the edges of the cut-blocks. The smaller groups that were left had fewer large snags, and that was one of the objectives –to maintain snags for canopy-nesting birds. The smaller groups were certainly more vulnerable to wind damage than larger patches. Large groups tended to maintain more of the so-called forest-dependent species that ranged from beetles to birds. Logging costs were much lower where there was a small number of large groups versus a greater number of small groups. All of these factors were illustrated in a simple representation of the thought process, and the results were clear: certain objectives were met with different alternatives of retention systems (large groups, small groups, or dispersed single trees).

The AM working group coordinated the process and provided the company with science-based recommendations and scientific advice from time-to-time – and the company management team ultimately had the power to make the decisions about company policies. If the management team approved changes to strategies, policies or standard operating procedures, this often led to new programs and new field projects. This kind of assessment and adjustment of practices took place over the last 5-6 years (previous to the workshop). The results obtained from the approach described above (e.g., VR) helped to redefine the company's strategy, and such adjustment was *"what we are calling the 'new western forest strategy', so we have been through at least one AM cycle over the course of things and we hope to continue that continual loop"* (Beese, quote from the workshop).

The data has to connect to the questions, which means it has to connect to the management options that are available to you. So you try and design a program around the questions but the most important question is always this: if we had the data, would we do anything with it anyhow?

In conclusion, the AM program helped the company to learn how to operate on the ground and improve management practices. At the same time, the program evaluated ways to maintain ecosystem representation in both the managed and the unmanaged land-base, and habitat elements in stands. Major challenges were:

- The acquisition and interpretation of data regarding single species.
- The long-term commitment for success and further development of the AM framework.
- The ongoing struggle for economic profitability of the timber business, mainly due to strong external forces.
- The maintenance of public involvement, which seeks to ensure ongoing social acceptance**,** presently achieved through strategies like 'The Coast Forest Strategy'.

Extracts from discussion

B. Beese: *"It's been hard to tease that out of the data, but it does seem like maybe those types of events are not as rare as we thought, because it seems like every five years… I'm saying: we've had another catastrophic wind throw event that was not expected. So maybe they're not quite so unexpected".*

L. Kremsater: *"You've undergone some very similar challenges in that the small company that started it –MacMillan Bloedel– had a new CEO that said: 'you're not going to clear-cut, you're going to do something different, and you need to tell me it works'. You had AM change of practices right there. You didn't really have to create trust because it came from above… But then, when you went to become Weyerhaeuser, you had something convincing to do. And I think now, that you are combined with –Cascadia and Western Forest Products and Weyerhaeuser are all together – it's been a bit of a sales job to try and get this into a larger picture".*

F. Bunnell: *"I think this is a general issue in resource management: for some of the questions we ask, we're not going to see the consequences of actions for a long time. Then you have to try to convince somebody to monitor, which is long term. So it gets to be a trick of learning – as Bill mentioned – to deliver some things within the monitoring project that are beneficial to the funders over short periods so they can see the value of funding the longer term monitoring".*

At Session 2 of the workshop, Fred Bunnell (Department of Forest Sciences, UBC), provided an overview of his intellectual perspective on how science is incorporated in decision-making for AM. His overview was mostly based in the experience he gained by participating in the Forest Project. According to Fred Bunnell, the purpose of AM is to improve management through information gained on actions taken. The goal of science is to expose consequences of alternative management decisions as clearly as possible. Subsequently, he noted the following facts and guidelines about AM.

Simpler is not always better. Much of our design for increased effectiveness employs simple comparisons among operational practices/treatments. Those simple comparisons are valuable and informative but do not always include necessary complexity.

Don't expect tidy thresholds. Some physical relationships have clear thresholds – almost no biological relationships do. The best that scientists can deliver to decision-makers is a marginal value (or risk curve) and offer a clear interpretation.

You should not tell the stakeholders or your partners in this enterprise [of AM] that you are going to find trigger factors [tidy thresholds], because you are probably not going to. It is simply because they do not exist. It is almost always curvilinear.

Conflicting recommendations are inevitable. For almost all management issues, data will provide conflicting recommendations to management – because different desired outcomes respond differently to management actions. Conflicts can be exacerbated when different economic and social objectives are set for the same land base.

Informed choice and general guidance. Numerous, conflicting recommendations from scientists can overwhelm managers and be ignored. Decisions on best options or appropriate amounts are based on values, especially tolerance of risk and assumptions about the values of the resource. Valuation of results, however, is external to the data and monitoring results should be presented independently of specific values. Recognising that data are not equivalent to a decision, it is important to consider two different instruments for feedback of complex relationships to management – **informed choice and general guidance.**

Informed choice: most useful for evaluating choices among specific alternatives. Informed choice presents decision-makers with predictions of the effects of different, clearly specified management options on a number of valued components based on the best available science (e.g., Northwest Forest Plan). The decision-makers, who have responsibility for incorporating public values, decide which option or plan is best based on the information presented. 'Best available science' includes general published literature and monitoring results. Results can be formally combined with literature results (e.g., Bayesian analysis) or presented as additional material, unincorporated into analysis. The options to evaluate can be suggested by managers, scientists, environmental or other interested groups. The important point is that the predicted effects of the management options on anticipated outcomes are presented, rather than implicitly incorporating researchers' values by making recommendations directly or by using a summary score. The informed choice approach is useful when the number of clearly-defined options available for a particular management decision is limited.

As you're learning to monitor, you are actually doing research. The only real difference is the term. When you talk monitoring, you are talking long term.

The decision is almost always going to be made on the basis of social and economic concerns, so it will always be incomplete. Your job is to make it understandable and the consequences of these data that you have collected as clear as possible for the people that end up making the decisions –so you're trying to keep it fairly clear.

General guidance: helps sustain long-term improvement. Informed choice does not provide general guidance to management questions like: What should we be doing more or less of, or doing differently altogether? Or what issues will we be facing in 10 years? Guidance on these kinds of questions happens best through a group of people with ready access to monitoring results and other information, and who can use their expertise and judgment to decide which are the most pressing problems or issues and what solutions or ways of improving are possible. The nature of the group or groups and ways to *"institutionalize"* the approach should be considered (e.g., the International Science Panel and Variable Retention Working Group for The Forest Project, coastal BC).

A major challenge to monitoring is to meet immediate needs while anticipating future needs. The differences between informed choice and more general evaluation and guidance reflect two underlying challenges to monitoring programs. The first relates to the length of view – short term versus long term. Specifically, is the monitoring program intended primarily to help with short-term management problems by choosing between currently available options, or is it intended to provide long-term guidance towards an ever-increasing ability to attain some overall goal? The second distinction is whether the program reflects efforts to 'mitigate' (find the least-bad current option) or to 'do good' (work towards a better condition).

The scholars that deal with decision theory and problem analysis have a special group of problems that they call 'wicked problems'. Those are the ones for which there is no right solution. There is no right answer. You know what's better and what's worse, but there's no right answer.

Predictions will be wrong. Complex natural systems contain too many 'black swans' (unexpected events with large impacts) for predictions to be accurate. The problems are usually 'wicked' – "…class of social systems problems which are ill-formulated, where the information is confusing, where there are many clients and decision-makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (Buchanan 1992). The monitoring should be designed to anticipate surprises and distinguish between better and worse – 'best' has no role. There is no single 'correct' path, but you may be able to avoid the deepest ditches.

Expectations from monitoring may be naïve. It is probably naïve to expect direct short-term management response to monitoring results in the face of strong economic pressures. Even though approved by President Clinton, the Northwest Forest Plan was not implemented as designed (Molina et al. 2006). At best, people overseeing a monitoring program can provide selective forces that help keep the monitoring useful in the long-term. Most major management issues are too thoroughly examples of wicked problems to permit simple solutions. Feedback loops may work for simple operational questions. Broader-scale changes are more likely to be based on information

Create institutional structures to encourage feedback, action and support innovation – those that study innovation find out that 95% of innovation comes from the guys on the ground.

received less directly, as recommendations from people who integrate many information sources (e.g., International Science Panel in The Forest Project, market groups or policy-makers). Because such recommendations are partly informed by science, a monitoring program can make an important contribution by generating sound scientific results. These may ultimately have more impact on improving management – by whatever indirect route – than monitoring attempting direct, immediate feedback to management decisions.

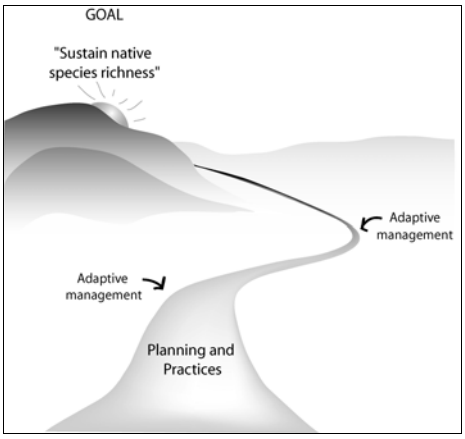

Figure 11. Adaptive management as conceived within 'The Forest Project'

"Adaptive management provides the 'rumble strips' to avoid drifting off the road and into the ditch. AM provides course corrections to the road map provided by planning and practice" (Fred Bunnell, quote from the workshop).

You know, when we began this, Carl and I both arrived at UBC about 1970 and those grad students –Ray Hilborn and Randall Peterman– were working here. All of we were trying to work towards a structured form of learning, because we knew that management was going to happen anyhow. So, is there a way you can learn from your management?

For a government or company, conducting sound scientific projects (even if not directly applied) can be seen as 'rent' for the use of the broader scientific knowledge that is the fundamental basis of informed management decisions. With an ever-changing organisational environment for monitoring, and the inherent interests of most researchers, good scientific contributions may be the main legacy of a long-term monitoring within an AM program. Ultimately, monitoring may lead to improved practices not by direct feedback, but by serving as a frequent reminder that particular practices are valued for more than their economic contributions.

Extracts from discussion

F. Bunnell: *"…somebody can come up with a really bright idea but they don't know how to make it work. The people who are actually on the ground, actually doing things, can usually figure out a way to make it work. So it's not going to be academics that figure out how to make a new practice work. They'll have some suggestions. They'll have some idea of what it should do. But there's other people that are going to be able to make it work far better than almost all academics".*

L. Kremsater: *"I'll always remember one of the first times we were thinking about increasing retention in the coastal forest up here. They were already doing some retention in Oregon and we had a workshop there. We went down with some forest engineers from MacMillan Bloedel. It took some selling to them that this increased retention was a good thing, but after just listening during this workshop – this was before the forest project – the drive home was: 'oh, we could do that same thing. We've got bigger trees. It'll be hard but we can do this'. They figured out how to make retention a reality in coastal forest when people used to say, here in B.C.: 'there is no way you're going to retain that much forest; with trees this tall, it's too tough".*

P. Higgins: *"You have to understand the fundamental ways that things work and the tolerances of the system, and the only way you can do that is by having the responsibility of operating that system. You won't know when you can open your gates or how you open the gates for your wetland, unless the guy that you know does that or the farmer picks up the phone and says: 'hey! What are you doing?' You have to understand all of that".*

L. Santamaría: *"…there was something coming from above. Supporting that. Now, you want to do something that works, but you are working against establishment. How do you go?"*

F. Bunnell: *"Slowly, and persistently…If you want it badly enough, then you have to commit the time… somehow you have to get the people that actually change things, to be changing things, right at the beginning, and I think it's easier to give them broad outcomes and tell them you're not really sure how to do this but it would be so much better if this could happen".*

L. Kremsater: *"The programs would just die if the person involved doesn't shift from being a science researcher and become a political champion or something".*

Bunnell was followed by a second presentation by Warren Warttig (International Forest Products Limited) at Session 2, about the main challenges facing the interface between science and policy. Although his presentation was not directly related to the Forest Project, I included information about it here because it dealt with the recent history of BC's forest management policies. He defined such interface as "all about utilising

scientific knowledge more effectively, thereby creating more value, more quickly for society from forest research". He First reminded the audience, in order to make contrast with the current reality, the recent history of BC's forest management policies, which for one hundred years (1880-1886) were based on utilitarian approaches, focusing primarily on socioeconomic factors. Sustainability issues were then based on timber resources, with other (environmental) values having limited consideration. Between 1986 and 1988 such focus was maintained, but there was a general recognition that timber resource management was impacting the fisheries resource and the drinking water. In 1988, the Fish Forest Guidelines were implemented. The public started to recognise other, non-utilitarian values.

We are practitioners, we are foresters. So, are we doing the right thing? With that, to interpret whether we're doing the right thing, that's where the effectiveness monitoring, AM programs come in. They are a tidy way of saying: be objective and non-biased in the result. And that's your social license. Social license is your trust.

In 1995, the BC Forest Practices Code was elaborated. This policy document recognised the increasing emphasis on balancing socioeconomic values with environmental ones. The same year, the Clayoquot Scientific Panel made its recommendations and prescribed ecosystem-based management. This turned the emphasis into ecosystem functions like primary and secondary productivity. In 2001, the Forest Range and Practices Act shift the focus on results, and emphasised professional reliance. More recently, in 2004, the Central and North Coast Ecosystem Based Management Handbook (EBMH) came up with an overarching plan mainly for the protection of environmental values. However, many monitoring plans still lack the input from academia.

Granting agencies have the tendency to fund research ideas that have a sexy title. It has a tendency to pull it away from a central theme and to this day, I'm not aware of a university that has a strategic research program where they have different faculties trying to build on knowledge in a cumulative manner rather than a jigsaw puzzle manner.

For example, in 2001, as part of an effective monitoring program for Landscape Unit Plans, three regional workshops were held involving representatives from the Ministry of Environment, the Ministry of Forests, Environmental NGO's and Forest Industry, but there were not representatives from the academic world. Where was the academia then?

Has academia expressed concern? Why scientists are so far removed away from policy makers and practitioners? Warttig asked.

In his final summing-up, Warttig stressed that the main point of his historical review was that *"there has been a clear shift in BC from management for timber extraction with an emphasis on socioeconomic values, to management for primary and secondary ecosystem productivity without addressing socioeconomic values"* (Warttig, quote from the workshop). He noted then that the question is how to find the balance between the social, the economic and the environmental realms, in order to meet completely the community values. For that, he addressed, practitioners need effective policy, credible scientific input, and effective communication among scientists, policy makers, and practitioners. Also, practitioners need effectiveness monitoring and AM programs – *"perception of objective, non-biased results ('social license')"* (Warttig, quote from the workshop).

For example, the Sustainable Forest Management Network is internationally-recognised for delivering a world class interdisciplinary program that undertakes relevant university-based research, and involves diverse sectors into a partnership of funding, planning, and implementing sustainable forest management research (government, industry, academia and granting councils).

Actually the first step in AM is the literature. Make sure you're not recreating something.

Warttig concluded that, in order to work effectively at the interface of forest science and forest policy, several guidelines must be taken into account, including:

- Focus research on questions that are relevant to policy issues.
- Conduct research in a communicative and collaborative manner.
- Understand the process of serving and engaging policy processes.
- Create organisational capacity and culture that enables and encourages work at the science-policy interface.

Further conclusions by Warttig were that scientific information is rarely the primary driver of policy change, policy-makers respond more readily to research that affects their constituents' needs (values that are unsatisfied or at risk of being lost). People's values should be considered in planning, conducting, and implementing research, and a clear focus on needs enhances the effectiveness of forest research and its influence on policy-makers. As regards research, he stressed that research that is both interdisciplinary and integrative is needed (i.e. collaboration), and that researchers should consider the role of science in policy implementation. Finally, he concluded that researchers must remain independent, neutral and unbiased.

Extracts from discussion

C. Menzies: *"It was interesting that you mentioned: values change or forest conditions change… I'm curious that you don't mention a third: the interests of the forest themselves… if you only see the driving forces to forest policy as being: changes in value or forest conditions, that basically means that the forest companies themselves are, in a sense, innocent and naïve participants, acting in conditions over which they have no control… I'm suggesting the third key answer to that is the economic interest of the forest corporations and it's been that way from the beginning".*

Finally, Laurie Kremsater (Department of Forest Sciences, UBC), at Session 3, made a presentation on her work together with Fred Bunnell and Bill Beese, in the Coast Forest Strategy indicators monitoring program and on how to link results to management (i.e. feedback to change actions). The CFS strategy organised monitoring around three indicators:

- Indicator 1: Ecologically distinct ecosystems are represented in the non-harvestable landbase of the tenure to maintain lesser known species and ecological functions.

We said: we need a certain proportion of each distinct ecosystem represented in an unmanaged state. We had reasons for that. There's a rational here. That looks after the species we don't know too much about. It looks after ecological functions. It provides a baseline for our research. So we have reasons; we have objectives for the indicator.

- Indicator 2: The amount, distribution, and heterogeneity of stand and forest structures important to sustain native species richness are maintained over time.

- Indicator 3: The abundance, distribution and reproductive success of native species are not substantially reduced by forest practices.

Then we had this third group of indicators to monitor all around species. And again, there was a rational to do this. Species really are what the public responds to. Genetics, which are factored by species, but really what allows things to adapt, to be resilient to changing environments. So species are important.

Before embarking on monitoring, the AM Working Group thought through how feedback from each indicator could link to management. The possible management actions ranged from relatively complex to relatively easy to implement.

And as information comes in over time, we'll know what structures are to be maintained. What we are doing well operationally and what we're doing not so well operationally.

Potential Feedback:

- For indicator 1, ecological representation, knowing what ecosystems are weakly represented in the unmanaged land base allowed several possible actions:

1. Relocate parts of the old growth zone or allocate parts of the habitat zone to under-represented areas.
2. Add protected areas (such as Old Growth Management Areas) to those ecosystems.
3. Increase riparian buffers or other landscape level features (e.g., Deer Winter Ranges or Wildlife Habitat Areas).
4. Increase levels of stand level retention in those ecosystems.
5. Focus monitoring on those underrepresented ecosystems because these are the ecosystems where variable retention will be the major means of maintaining some species and therefore should be the focus for monitoring organisms and structures.

The feedback that required keeping all ecosystems above some arbitrary target was not included, but rather actions were aimed at improving the weakest areas.

- For indicator 2, landscape and habitat structures and patterns, feedback could involve several actions:

1. Comparisons of VR (Variable Retention) blocks to benchmarks can suggest structures that are retained well by VR and those that are not, so that efforts can be made to improve retention of such structures.
2. Comparisons of structures retained under different types and levels of VR could suggest best mixes of VR to use to create variety of structures on landscape.
3. Information on what structures are found with different patch 'anchor types' could suggest different features to which patches should be anchored.
4. Information on edge effects can help choice of block layouts, retention sizes and shapes.
5. Operational progress over time can indicate if improvement is being made in retaining variety of structures.
6. Landscape patterns can be compared over different management scenarios and scenarios chosen that maintain more interior, create less road, and create less edge.
7. Long term trends in landscape patterns and stand-level structures can expose priorities for improvement.

- For indicator 3, species, feedback focused on identifying indicator species, but over the longer term information on species will link to management by:

1. Shifts in range may indicate gains made by modified forest practices.
2. Linking species to VR levels and types. Feedback then involved assessing which species were most sensitive to practices and monitoring their trends.
3. Linking species to particular structures, and then tracking abundance of structures to suggest provision of habitat for the species.
4. Patterns of organisms around edges can assist block layout.
5. Linking species to landscape patterns and suggesting adequacy of habitat via modelling.
6. Species associations can assist modelling to project over long-terms and large areas.

Actual Feedback: Feedback on representation focused on monitoring in extensively managed areas. The under-represented ecosystems fell largely on private lands where there was reluctance to establish Old Growth Management areas of increase retention levels in those ecosystems. Some effort was directed at riparian restoration in those ecosystems, but not beyond typical FRPA guidelines. Monitoring occurred in these ecosystems, but they have not been the focus.

Comparisons to natural benchmarks identified structures that needed more attention during VR. Those were improved and confirmed by operational monitoring over time – a direct monitoring feedback. Also, comparisons indicated group VR functioned better than dispersed VR for retaining many structures, but that dispersed retention kept some structures (e.g., large live trees) better than group VR. AS a result, the mix of VR types shifted to more group retention, but dispersed retention was also maintained. Work on how choice of anchor points affects structures showed rocky outcrops tended to support poorer structures. Results of operational changes have not yet indicated if anchors have shifted from those types.

> *How do you know what areas need work or what's weak or what's better? Well, you learn that by comparisons. We use comparisons of different retention levels, different retention types; we decide those are the things we are willing to play with.*

Linking species studies to management is the least developed area so far and the most difficult to achieve. Patterns of bird abundance to retention level have been investigated and sensitive species identified; these species are tracked through continuing Breeding Bird Surveys. Some pilot efforts at modelling landscapes have examined interior, edge, roads and responses of lichens and birds for different scenarios. Those scenarios were not driven by choices facing the company but rather were academic investigations. Without practical scenarios to compare and choose among, the landscape associations are unlikely to link to management. With the multiple changes in company ownership, maintaining communication between researchers, managers and forest operators has been a challenge. Efforts continue to close the feedback loop.

Extracts from discussion

L. Kremsater: *"You can improve your structure; you can improve your unmanaged land-base or some species that you can look after if you do this or that. But when you get to starting to balance it, you start to look at the range of species that we monitor and compare that to what kind of retention do you do here and here and here and here over a whole landscape, it gets so complicated".*

B. Beese: *"We're getting five-year results now for just about everything and we're up to eight years on landscape level breeding-bird surveys. So that's the one linkage we have between stand level monitoring and landscape is the birds".*

W. Warttig: *"So, that's where I think the models come in, at that level".*

L. Kremsater: *"It does. I guess I have a real hesitation about some models too. I think that having the science panel, with scientists that are knowledgeable of this from the beginning, and can take some of the stand level studies and the landscape bits that we do have help merge those into whether you think the overall direction is good or not. Or whether there should be additional studies or additional experiments set up. That's been a really useful, if expensive, tool to use to help guide us".*

3.3.3.3. Jumbo Glacier Alpine Resort

At the second presentation of Session 1, Mike Harstone (Compass Resource Management) presented several propositions for facilitating AM. He referred to a project his company is involved with: the Jumbo Glacier Resort (East Kootenay, BC)[21]. According to Harstone, the project has been in the environmental assessment review process for over fifteen years, largely because public participation remained low and there were huge concerns associated with its effect on the conservation of Grizzly bears (the affected area is of key importance for maintaining the flow of genes between Canada and the USA). This place also happens to be, from a cultural perspective, the place *"where the spirit of the Grizzly bear resides"*. To First Nations, this is the most sacred place when it comes to Grizzly bears.

[21] Jumbo Glacier is a municipality planned to be a year-round skiing mountain resort. Its development has been the subject of public controversy the last two decades for politico-economic and environmental reasons.

After fifteen years in review process, the provincial government finally approved the project arguing that it would not have *"population level effects on the Grizzly bears"*. *"Why do you need AM?"* (Harstone, quote from the workshop). There is a difference between uncertainty, the need to learn, and urgency, the need to take action. AM is in an intermediate position between conventional management, which focus primarily on management objectives, and basic research, which focus mainly on learning objectives (Marmorek et al. 2006). AM is a systematic approach for improving resource management by learning from management. However, despite the fact that learning plays a key role in AM, it is a means to an end, namely good management, and not an end in itself.

> *So you are delaying making those propositions (about trade-offs) now whereas you should integrate them up front. And as a result, as you get into the monitoring phase of the study, it is the first thing to be chopped. And therefore, you are just kind of running blind again.*

AM is warranted when a real management decision is to be made, there is an opportunity to learn and the value of information for decision making is high –*"as something will change"* (Harstone, quote from the workshop). A clear and measurable identification of management objectives is also needed. In that sense, uncertainties must be expressed as explicit hypotheses, a monitoring system is crucial to reduce them, and long term commitment and decision reviewing is essential –*"so that actions can be adjusted"* (Harstone, quote from the workshop).

There are several factors that often make AM programs doomed to failure:

- Overlapping roles among actors (mainly managers and scientists).
- Low institutional nimbleness.
- Confusion between science (facts) and values.
- Hidden trade-offs behind AM.
- Lack of definition for triggers/impacts thresholds.
- Lack of committed funding for monitoring.
- Limited opportunity for meaningful involvement by affected First Nations and other stakeholders.
- Lack of structured formats to review and address duelling knowledge claims.

What would an AM program look like? What First Nations wanted to do was really clear: what were the triggers? In other words: when would the government actually have to do something? What are the impacts on other stakeholders? What are the costs associated with that?

However, there are several opportunities towards the attainment of successful AM programs in the framework of the Jumbo Glacier Alpine Resort project, including that:

Glen: *Five minutes more.*

Mike: *Did you actually stop the clock?*

- Affected interests (objectives) must be explicitly built into the AM planning framework and linked to the decisions or actions. There is a need to generate buy-in and build partnerships in the early stages of the planning process.
- AM should structure and inform dialogue about the trade-offs among multiple objectives.
- The link between actions and objectives should be the focus of AM. Explicit objectives are needed to guide decisions about what actions to take.
- Scientists need to understand how their input fits into the multiple objectives that managers (decision makers) must balance.
- The purpose is not to develop complex predictive models that are "*right*", but to enhance learning by allowing comparison between expected and observed outcomes thereby improving hypotheses and predictive capability over time (e.g., starting by expert elicitation to develop hypotheses and assess expected outcomes over a set period of time).

What is needed for success (by Mike Harstone)

- Leadership and partnership
- Clear links to planning or decision making processes
- Early and systematic First Nation & stakeholder involvement
- Relevant science
- Explicit objectives and performance metrics
- Recognition of and constructive approach to tradeoffs
- Explicit hypotheses
- Commitment to ongoing monitoring
- Secure funding

- AM triggers will never get sprung unless there are clearly defined impact thresholds that are agreed to upfront. There is a need to be clear not just about what actions have been adopted and are currently being implemented, but which actions we foresee wanting to consider in the future.
- AM success will be judged by the extent to which decisions are changed, and on-ground results improved as a result.

Extracts from discussion

M. Harstone: *"When we get involved with projects, a lot of times, if you're a scientist, it's an evaluating process sometimes. It's the rare scientist who'll say: 'well, here are the facts'… It's like they have a value about how they think that resource should best be managed".*

C. Menzies: *"I'm sorry but that presupposes that you actually know what the facts are. I mean: I see it like this. The whole thing about values versus facts. You're embedded in the entire process… [your position] is going to shape what you do in your work for a corporation, that's going to shape what you do when you're an independent researcher. You are not doing any value-free science… What I think you were saying in terms of value is more a perspective or orientation that leads one to act in a particular way".*

P. Higgins: *"For example, what you're talking about is how you choose the level of, say, statistical error. You'll choose in a science experiment. There's type one and type two errors, and the way you choose those, expresses how much you don't accept uncertainty".*

M. Harstone: *"A lot of times, how you set up an AM experiment confuses those two things [facts and values], and you need to be explicit about recognising that there are those two very different things… different people will put different weight on whatever the attributes are associated with that value that's been expressed…. But then, at the end of the day, in terms of what the management options are, it might not actually come into play. Or in some cases it might. But, at least, you've structured things in a way so you don't get hung up on the semantics of some of the things that seem to really challenge people".*

G. Hearns: *"I think a lot of times AM is used as a cloak to hide behind. Because there's uncertainty now, there's tough trade-offs in terms of stakeholders views or First Nations views that people don't want to take right now. It's like, we got consensus in the room right now because we're going to do an AM approach. And they put off these tough trade-offs that they know will never get revisited because when you do a review it's not as much effort as when you developed the plan the first time".*

L. Kremsater: *"Within AM, you set up objectives for success in some cases but you*

also set up situations where you're really trying to learn, not sure if those management choices are your best ones. In fact, sometimes you know that they're not going to be your best ones but they're helping you learn".

3.3.3.4.Water Use Planning process in BC

Paul Higgins (BC Hydro), closed Session 1 with some pieces of wisdom derived from implementing AM programs over 23 watersheds in BC. He started with some background on the water use planning process in BC. 'BC Hydro and Power Authority' is a Crown company (public company) that promotes green energy development, through sustainable water use. The goal or BC Hydro Water Use Plans (WUP) is to find a balance between power and non-power uses to meet contemporary standards for water resource management. BC Hydro has a $25 million (CND) budget to establish WUP over 5 year schedules. The physical power of the company resides in its stewardship of 42 hydro-facilities over 23 watersheds, the capacity of producing 9800 MW of hydropower, and more than 100 diversion licenses. BC Hydro acknowledges AM. Within the company, it is recommended as a preferred policy approach to manage time scope and scientific uncertainty issues in the development of WUP, without making changes in the company legal or constitutional rights (to generate power).

And the issue we had is that we didn't have very much scientific information on our facilities that would help us make good decisions. We had a very short time period to make these decisions. AM has turned out to be a blessing because of the way it's been embedded into our licenses. It's given us an approach to move forward.

Why should we use AM? Because it would allow us to manage our data gap and time scope issues and in theory it's a defensible approach to improve management.

The WUP consists of several phases. Once initiated the process and the consultative activities, major steps are: (1) the confirmation of issues and interests in terms of specific water use objectives, (2) the gathering of additional information on the impacts of water flows on each objective, (3) the creation of operating alternatives to meet different interests, (4) the assessment of trade-offs among operating alternatives in terms of the objectives, and (5) determine and document the areas of consensus and

disagreements. Final steps include monitoring of WUP compliance and its review on a periodic and ongoing basis. The key principles of the WUP making process are:

- The recognition of multiple objectives and uses (wildlife conservation, First Nation values, fisheries, recreational).
- Making it a collaborative, cooperative and inclusive process.
- No constituting it as a force of change in legal or constitutional rights.
- The recognition that trade-offs have and will occur.
- The embodiment of science and continuous learning through information gathering and analysis.
- The focusing on issue resolution and long-term benefits.

AM has an emphasis on long-term improvement. Environmental management can have an emphasis on short-term improvements. AM considers that you have to think about the value of information. AM really focuses on one aspect of a problem, but it's in the context of a whole lot of other things.

There is a need to address trade-offs across AM and other environmental management objectives. AM is an option nested within an overall environmental management program, frequently attempted for the wrong reasons or at the wrong scale – "*water management issues can be too diverse and complex to be resolved under one 'umbrella' AM strategy*" (Higgins, quote from the workshop). Some problems just don't suit adaptive approaches or the system is too rigid to accommodate the needed trials. Also, the viability of an AM initiative is related to the consequences of information for management in relation to the chance of getting it. As Failing et al (2004) have addressed, issues being addressed by AM must be related to the most important objectives to justify deferring decisions related to other objectives (management relevance).

There is no silver bullet, but one of the big things that we knew was that we needed to develop trust, so we spent a long time working with people, learning about their values, taking their values seriously, teaching them about the limitations of the operations of a hydro-facility and what could be done and what couldn't be done and what normally happens.

The key factors controlling the viability of AM programs are: (1) spatial and temporal scale of the problem (duration and spatial complexity), (2) technical uncertainty

(model structure and parameters, stochastic and systematic confounding effects, indicator choice), (3) stakeholder and institutional support (institutional capacity, leadership, trust, flexibility in decision making), and (4) costs, benefits and risks (perceived risks of failure).

For P. Higgins AM is seductive and intoxicating but can have a dark side, as it can produce costly decision making processes resulting in the postponement of difficult decision. Managers can perceive that scientists are promoting costly experiments in the pursuit of scientific knowledge as an end in itself; and it builds management and stakeholder expectations that sometimes will not be delivered.

In some cases, AM just doesn't suit the problems that you're trying to get. But because people like AM, they think it's the new way to go, you try to embed it in an AM rather than an environmental management framework –you might be misguided and not have the success you're looking for.

Extracts from discussion

J. Amezaga: *"Trust. To have trust, you must be trustworthy. What kind of trust are you talking about? Personal trust? Trust in the process? Trust in the outcome?"*

P. Higgins: *"…each of these water use plans took about two years to develop. The first six months of that was spent just finding out what [First Nations] people cared about… until I had understood what their value system was, they wouldn't talk to me…and then, once they were talking to me, I could tell them about how difficult it is to run a hydro-facility… I think that developing trust is like you develop trust with anybody. It takes time".*

M. Harstone: *"I think it's quite fair to say that the hydro-engineers didn't have much trust if they didn't see why they were being told to do in their jobs well and they were reticent sometimes to participate or to give information…It was as much internal turmoil, I would say, in terms of how the water use planning got carried out as well as it was the external one in terms of long-standing trust issues".*

P. Higgins: *"Trust is something you have to earn".*

The core lessons and insight gained in the Vancouver workshop are synthesised in Tables 8 and 9 below.

Table 8. Summary of conclusions of the speakers of the AM workshop – Opportunities and challenges for AM

	Conclusions	
Speaker	**Opportunities for AM**	**Challenges for AM**
Bill Beese	- Increasing pressure in the global market place for wood from forest certified as sustainably managed. - Variable retention procedures. - Collaboration with academics in the development of feasible and realistic objectives, and reliable indicators. - Executive (i.e. from-the-top) willingness and support. - Learning.	- The acquisition and interpretation of data regarding single species. - Long-term commitment for success and further development of the AM framework. - The ongoing struggling for profitability of the timber business mainly due to strong external forces. - The maintenance of public involvement.
Mike Harstone	- The explicit building of affected interests into the AM planning framework and their linking to the decisions or actions. - The structuring and information of dialogue about the trade-offs among multiple objectives. - The link of actions and objectives, as the focus of AM. - The understanding of scientists of how their input fits into the multiple objectives that managers (decision makers) must balance. - The acknowledgement that AM serves the purpose of enhance learning by allowing comparison between expected and observed outcomes, thereby improving hypotheses and predictive capability over time. - The upfront agreement of clearly defined impact thresholds.	- Overlapping roles among actors. - Low institutional nimbleness. - Confusion between science (facts) and values. - Hidden trade-offs behind AM. - Lack of definition for triggers/impacts thresholds. - Lack of committed funding for monitoring. - Limited opportunity for meaningful involvement by affected First Nations and other stakeholders. - Lack of a structured format to review and address duelling knowledge claims.
Paul Higgins	- The analysis of trade-offs between AM and other environmental management objectives. - The adequate trade-off between the consequences of information for management and the chance of getting it.	- Systemic rigidities. - The production of costly decision making processes resulting in the postponement of difficult decisions.

Table 9. Summary of conclusions of the speakers of the AM workshop – Critical facts and guidelines for effective AM

Speaker	Critical facts and guidelines for effective AM
Fred Bunnell	- Simpler is not always better. Simple comparisons among operational practices/treatments are valuable but do not always include the necessary complexity. - Don't expect tidy thresholds. Some physical relationships have clear thresholds – almost no biological relationships do. - Conflicting recommendations are inevitable. For almost all management issues data will provide conflicting recommendations to management – desired outcomes respond differently to management actions. - Informed choice and general guidance. Informed choice presents decision-makers with predictions of the effects of different, clearly specified management options on a number of valued components based on the best available science. General guidance helps sustain long-term improvement. - A major challenge to monitoring is to meet immediate needs while anticipating future needs. - Predictions will be wrong. Complex natural systems contain too many 'black swans' (unexpected events with large impacts) for predictions to be accurate. The problems are usually 'wicked'. - Expectations from monitoring may be naïve. It is probably naïve to expect direct short-term management response to monitoring results in the face of strong economic pressures.
Paul Higgins	- Spatial and temporal scale of the problem (duration and spatial complexity). - Technical uncertainty (model structure and parameters, stochastic and systematic confounding effects, indicator choice). - Stakeholder and institutional support (institutional capacity, leadership, trust, flexibility in decision making). - Costs, benefits and risks (perceived risks of failure). - Key principles of the Water Use Plans making process in BC (based on AM tenets): 1. The recognition of multiple objectives and uses (wildlife conservation, First Nation values, fisheries, recreational). 2. Making it a collaborative, cooperative and inclusive process. 3. No constituting it as a force of change in legal or constitutional rights. 4. The recognition that trade-offs have and will occur. 5. The embodiment of science and continuous learning through information gathering and analysis. 6. The focusing on issue resolution and long-term benefits.

Table 9 (cont'd). Summary of conclusions of the speakers of the AM workshop – Critical facts and guidelines for effective AM.

Speaker	Critical facts and guidelines for effective AM
Warren Wartigg	- Guidelines for an effective adaptive-management-based science-policy interface: 1. Focus research on questions that are relevant to policy issues. 2. Conduct research in a communicative and collaborative manner. 3. Understand the process of serving and engaging policy processes. 4. Create organisational capacity and culture that enables and encourages work at the science-policy interface. - Scientific information is rarely the primary driver of policy change, policy-makers respond more readily to research that affects their constituents' needs (values that are unsatisfied or at risk of being lost). - People's values should be considered in planning, conducting, and implementing research, and a clear focus on needs enhances the effectiveness of forest research and its influence on policy-makers. - Research that is both interdisciplinary and integrative is needed (i.e. collaboration). - Researchers should consider the role of science in policy implementation and must remain independent, neutral and unbiased.
Laurie Kremsater	- Some operative lessons from the Coast Forest Strategy indicators monitoring program: 1. Comparison to natural benchmarks identified forest structures that needed more attention during Variable Retention programs. Those were improved and confirmed by operational monitoring over time – a direct monitoring feedback. 2. Operational progress over time can indicate if improvement is being made in retaining variety of structures. 3. With the multiple changes in company ownership, maintaining communication between researchers, managers and forest operators has been a challenge. Efforts continue to close the feedback loop. 4. Landscape patterns can be compared over different management scenarios and scenarios chosen that maintain more interior, create less road, and create less edge. 5. Long term trends in landscape patterns and stand-level structures can expose priorities for improvement.

3.4. Concluding remarks

This chapter has documented the Canadian experience with adaptive management, with an emphasis on British Columbia. In particular, it has assessed a series of case studies in which particular institutional developments have allowed for the implementation of adaptive management in initiatives for natural resources management and nature conservation. Based on the assessments, information and findings reported above, the following concluding remarks can be made:

- In British Columbia (Canada), adaptive management (AM) has cycled during the last four decades through alternate phases of theoretical development, practical implementation and feedback (public workshops and debate), to which many scholars and practitioners have contributed.
- This process has provided AM theorists and practitioners in the fields of natural resources management and nature conservation with a complete and diverse body of knowledge on the subject (AM body of knowledge, AMBoK hereafter).
- Along history, the practical implementation of AM in Canada has faced a number of institutional opportunities and constraints. At the constitutional level, the institutional regime for natural resources management and nature conservation was characterised by a continuous trial of strength between the federal and the provincial governments, with a legacy that has endured to date. Indeed, during the last decades, the provincial and municipal governments have progressively increased their stewardship powers and duties over management and conservation – leading also to processes of institutional (i.e. organisational, legal and scientific-technical) convergence and coherence in some socioeconomic sectors (e.g., forest sector).
- In the Clayoquot Sound, the process of de-centralisation and institutional convergence represented a necessary step that empowered the BC Government to introduce, from the top, key institutional innovations (e.g., the creation of the Scientific Panel for Sustainable Forest Practices, SPSFP). At the collective-choice and operational level, the work of the SPSFP in the Clayoquot Sound revealed that the successful adoption and institutionalisation of AM required the convergence of several organisational, socioeconomic, conceptual and legal factors. The number of factors involved was considerably large because the social-ecological system faced a great deal of complexity, uncertainty and historical conflicts. The successful implementation of AM initiatives at the Clayoquot Sound and its surroundings (e.g., Vancouver Island, BC Coast) was made possible by the availability of an the AMBoK, which had been previously developed and evaluated at a number of small, pilot projects and sites in Canada and the USA.
- An additional key factor was the bottom-up *"successful, strategic, cooperation between academics and actors from the (forest) industry, willing to test alternatives to contemporary resource management and economic development*

strategies" (Fred Bunnell, quote from the workshop). Such factors were established formally and collectively by a diverse group of key regional actors (researchers, managers, foresters, socioeconomic agents and local communities), in a platform based on AM tenets.

- The "avant-garde nature" of the concept required a sustained effort for the collective understanding and agreement of its usefulness, and an institutional transition towards a more flexible, open-knowledge-based, and learning institutional regime.
- Such transition was also the result of a socioeconomic and ecological crisis (the so-called 'logging crisis'). This crisis constituted a historical event weighed down with uncertainty that was sufficient (but not necessary, nor unique) to trigger institutional change and innovation in the region.
- The Vancouver workshop allowed for eliciting current opportunities and constraints for the testing and implementation of AM in Canada, based on the direct, on-the-ground experience of practitioners and analysts.

The results of the TRANSAM project, combined with the AMBoK, provided the grounds and support for the strategic development of the action-research program in the Doñana region described in next chapter (Chapter 4).

Chapter 4. Action research in the Doñana region

4.1. Introduction

This chapter reports the rationale, specific objectives, methods and results of the action-research program carried out in the Doñana region[22]. The program was designed in several stages that largely paralleled the research activity of the TRANSAM project and the institutional analyses. Its context was the hydro-ecological restoration project Doñana 2005 and the pilot adaptive management experience in the Caracoles estate (see Santamaría et al. 2006), which were broadly recognised as an opportunity to introduce innovative approaches at the research management-interface. In applying action research, it was assumed that the intervention of "external insiders" with social expertise was needed to promote and facilitate a participative and inclusive process of change (based on Robson 2002). The general purpose of the program was to evaluate the instrumentality of action research for proactively introducing adaptive management tenets at the research-management interface. The main criteria to use action research was its usefulness for involving stakeholders in a project in which they were, at the same time, the focus of the research (see Chapter 1, Section 1.3). In particular, it was used as a broad, informal and participatory bottom-up means for introducing adaptive management tenets. Specifically, the methods described in next section were used to build trust among stakeholders, to facilitate their involvement in the program, and to produce policy guidance on the improvement of the research-management interface and on the introduction of innovations such as adaptive management. More generally, the program was used to propose improvements in water resources management and wetland conservation in Doñana at a broader geographical, policy and institutional level. This was realised through the involvement of stakeholders from a wide range of institutional and organisational levels, and by broadening the scale and scope of the discussions at the final workshop of the program.

[22] The research described in this chapter has been published in: Méndez, P.F., Isendahl, N., Amezaga, J.M. and Santamaría, L., 2012. Facilitating transitional processes in rigid institutional regimes for water management and wetland conservation: Experience from the Guadalquivir Estuary. Ecology and Society, 17(1), 26. [Online] Available at: http://www.ecologyandsociety.org/vol17/iss1/art26/

4.2. Methods

The following methods were applied at this research stage. First, I assessed the configuration of the institutional regime for water resources management and wetland conservation of the Doñana region, with a especial focus on the Doñana Nature Reserve. The aim was to understand and describe the history of the regime, as well as potential opportunities and constraints for adaptive management at the research-management interface. For that purpose, I sequenced and assessed the events that contributed to shape the current institutional regime between the beginning of the 19th century and the 2000s. At this research stage, the Institutional Analysis and Development framework (IAD) was used for guiding analysis, in complex systems thinking mode (as described in Chapter 2, Section 2.4), with the preliminary aim of providing analysis with institutional reasoning. Qualitative historical data were gathered through the review of the historic accounts available about the Doñana region and about other relevant events affecting the region. Data sources consisted of primary and secondary document sources, including: research articles and books, grey literature, technical reports, and policy and legislative documents[23]. The results of the historical assessment informed the design of the action-research program, which was regarded as an indispensable step for the process of change towards adaptive management. See Figure 12 for a depiction of the case study design applied to this research stage.

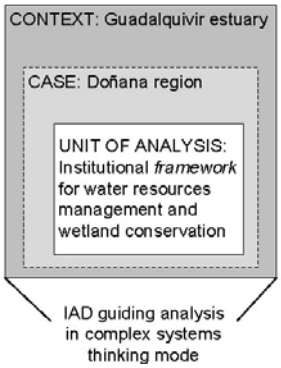

Figure 12. Conceptual design of the case and unit of analysis applied in the action-research program, in particular to the historical institutional assessment
Source: based on Yin (2009, p. 46)

[23] The constructed historical profile was a preliminary version of the data matrix included in Appendix 6, which builds on the mentioned profile to inform the in-depth historical institutional analysis carried out in Chapter 5.

Second, I performed an actor analysis to define an agenda for triggering participation (by whom, in what, when and to what end) in the action-research program. I selected and categorised actors on the basis of previously established criteria (Table 10), namely: (1) a historical criterion based on the prior historical assessment; (2) Mostert's four criteria for stakeholder identification (Mostert 2006, p.163); (3) the three analytical tiers of the IAD framework (constitutional, collective-choice and operational). Such criteria allowed me to classify actors in two categories: (1) decision makers, defined as actors with enough power to make a final choice among alternatives in policy making or project implementation processes; (2) stakeholders, actors who can affect or are affected by the achievement of new policy or project goals, or by the objectives of the action-research program. I contacted and interviewed actors with three main purposes: (1) to meet them in person and to inform them about the action-research program that we were undertaking; (2) to prepare the path for future participatory workshops through networking (i.e. generating social capital and cohesion opportunities), building trust, and establishing an agenda for participation; (3) to gather qualitative data for the long-term documentation of the program. Like in the TRANSAM project, interviews were semi-structured and open-ended, and designed to let the interviewees express freely and profoundly their ideas about the questions being asked. All interviews were preceded by a brief introduction about the TRANSAM project and the action-research program, and were guided by primary themes aimed at keeping the focus on those that were most relevant for such program. See Appendix 3 for the question guide.

Table 10. Criteria used for the selection and categorisation of actors in Doñana

Historical criterion
He/She or his/her organisation has historically participated in the past or recent development of the institutional regimes for water resources management or wetland conservation in Doñana
Mostert's criteria
A. He/She possess relevant information about the case study.
B. He/She can actively contribute to the development of new policy or projects.
C. His/Her interests will be directly affected by the action-research program and any potential process of change.
D. He/she can obstruct decision making or frustrate policy or project implementation.

Finally, we organised and facilitated two workshops. The first one (uncertainty workshop), carried out in collaboration with Dr Nicola Isendahl[24], was held as a focus group involving seven key actors for water resources management and wetland conservation in the Doñana Nature Reserve and the Guadalquivir Estuary (see Table 11 in results section). It aimed at identifying uncertainties in the mentioned sectors from the perspective of practitioners. The workshop first assessed how the participants perceived and framed uncertainty. In an open discussion, they identified several situations of uncertainty relevant to their professional work and, on the basis of these situations of uncertainty, shared parameters were interactively developed making use of the card-sorting method. The workshop was also meant at drawing the attention to the topic and at raising awareness about the issue.

The second workshop (research-management workshop) was carried out in collaboration with Dr Nicola Isendahl and our main Canadian partner in the TRANSAM project Dr Glen Hearns[25]. It involved a group of 24 actors (see Table 11 in results section). It focused on the improvement of the research-management interface in the Doñana Nature Reserve and the Guadalquivir Estuary. More specifically, it focused on collectively learning and developing knowledge about the challenges, constraints and opportunities identified in the first stages of the action-research program. The previous historical assessment showed that the research-management interface constitutes a critical element in the region, due to the historical weight of the competitive (often conflictive) trade-off between water resources management and wetland conservation goals. Moreover, most interviewees listed the lack of integration and coordination among researchers, managers and policy makers as one of the major challenges for enhancing the existing processes of decision and policy making in Doñana. The workshop consisted of three parts:

1. We introduced the action-research program and presented adaptive management as a potential tool to introduce dynamism and learning capacity into the research-management interface. As an example, we provided an overview of the results of the

[24] Institute of Environmental Systems Research (USF), University of Osnabrück (Germany). The collaboration of Dr N. Isendahl was possible due to funding from the NeWater Project (Contract no 511179, 6th EU Framework Programme). Currently at the Berlin Institute of Health (BIH).
[25] Institute for Resources, Environment and Sustainability (IRES), University of British Columbia (Canada). Currently the Principle at Aristos Consulting.

TRANSAM project. We also presented a list of challenges that might prevent the implementation of adaptive management, based on a preliminary analysis of the interviews of the action-research program and the results of the uncertainty workshop as follows (the list was placed visible to all the participants at the outset of the workshop in a whiteboard):

- The absence of a strategic framework for the region.
- The lack of water management and wetland conservation goals.
- The lack of a shared model of the structure and functioning of the Doñana wetland ecosystems.
- The ignorance of key uncertainties.
- The absence of pre-defined goals for monitoring programs (in spite of their long-term and coordinated character).
- The absence of evaluation and learning instruments (institutions, protocols, standards, coordinating individuals, champions, etc.).

This introduction was largely based on the lessons learnt in the TRANSAM project. We expected it to be broadly understood, since most of the participants had considerable knowledge about the rationale underlying adaptive management and knew of, at least, the pilot experiences applying it in the context of the Doñana 2005 and Guadiamar's Green Corridor projects.

2. We organised four thematic talks about nature conservation, research, water management and hydro-ecological restoration. They were presented by key decision makers and followed by facilitated discussion. In the discussion, several problems related to conservation, research and water management in the Doñana Nature Reserve emerged. The session concluded with the synthesis of such problems, their conversion into objectives and the elaboration of a shared list of recommendations to foster the improvement of the research-management interface (see below).

3. We organised a session of participatory modelling with only 15 of the initial participants (owing to agenda constraints of the rest). The activity was performed in two separated groups, respectively focused on two key components of the management of Doñana's aquatic ecosystems: water and vegetation. These elements

had been identified during the preceding interviews and historical assessment, as being both central to the management of these ecosystems and inter-related to most other relevant elements. We used Group Model Building as a method facilitating the sessions (Vennix 1996, Andersen et al. 1997). Each group, guided and moderated by a facilitator, worked on jointly building one causal model following a classic approach – focusing on simple processes to build causal relationships (see Vennix 1996). Both models were then presented in a plenary session and used for group discussion.

The workshops were also aimed at further informing actors about and building trust around the action-research program. They also allowed us to continue gathering qualitative data for the long-term documentation of the program.

4.3. Results

4.3.1. Historical institutional assessment

The Doñana region had a complex history of tightly coupled relationships between humans and water resources. The recurrent top-down operation of resource management and nature conservation policies and institutions contributed to the increasing isolation of the Reserve's marshland/wetland ecosystems. Nowadays, less than one third of the ecosystems persist, comprising 27,000 ha embedded in the Doñana Nature Reserve. The remaining marshland/wetlands are currently fed by intensively modified tributaries and streams, and it has been affected by decades of progressive degradation punctuated by ecological crises (e.g., waterfowl mortalities during the 1980s, mine pollution during the 1990s; Grimalt et al. 2000, García and Marín 2006). Several attempts to restore its 'natural' hydraulic-ecological regime (e.g., Casas and Urdiales 1995, García and Marín 2006) have been undertaken, with limited success.

During the 19th century, socioeconomic development in the Doñana region was characterised by the intensive exploitation of its water resources and the continuity of institutional arrangements (policies, regulations, scientific paradigms) aimed at the transformation of its aquatic ecosystems into productive (agricultural, afforested) lands. Management approaches to technical problems (e.g., hydraulic control, regulation of

drainage and irrigation) were largely based on engineering solutions (e.g., impoldering, canalisations) imported from abroad (Fernández and Pradas 2000b, García and Marín 2006). The most intensive transformations took place during the 1960s and the 1970s, during which plans and projects promoted and launched by the central government (e.g., Guadalquivir-FAO Project, Almonte-Marismas Plan) were controlled and carried out by the Civil, Agricultural and Forestry Engineering Corps (Fernández and Pradas 2000a). The ecosystems of the Doñana region were systematically transformed into a matrix of canals, sluice gates, pumping stations and bridges at almost sea level, aimed at 'optimising' drainage by gravity (Llamas 1988, Casas and Urdiales 1995).

Subsequent regulations entrusted the Spanish agricultural and forestry agencies with the stewardship of nature conservation (e.g., National Parks Act of 1916, Forestry Act of 1957, Nature Reserves Acts of 1975 and 1989). However, until the 1950s there was neither a real awareness about the social and ecological values of wetlands, nor were they considered as suitable for protection. In 1969, the aquatic ecosystems of the Doñana region became legally protected within the former Doñana National Park, owing to the effort of a small group of scientists and citizens who were aware of the risk of an imminent collapse of the ecosystem (Valverde 2004). The declaration of the National Park was preceded by the acquisition of large areas of marshland included in the Doñana Biological Reserve by the World Wildlife Fund for Nature (WWF); and paralleled the creation of the Doñana Biological Station in 1971, for research purposes (Fernández and Pradas 2000b, Valverde 2004).

The Ministry of Agriculture of the central government was in charge of the management of the Park for the first two decades. The management was soon in hands of the Institute for Nature Conservation (ICONA), created in 1971 by the merger of several forestry institutions within the Ministry. Subsequent regulations (Nature Reserves Acts of 1975 and 1989) increased the authority of the ICONA and reinforced the National Parks' legal systems. However, the historical dichotomy between the agricultural offices and the conservation/research institutions was consolidated in 1978, when the directorate of the National Park and the Biological Reserve was split between the ICONA (Ministry of Agriculture) and the Doñana Biological Station (Spanish Research Council, Ministry of Education). These two agencies received separated mandates: ICONA should manage the Park, while the DBS should guarantee its conservation. The conservation of the

Doñana marshes therefore depended on the institutional relationship between the DBS and the ICONA, which was itself facing an internal war among pro-conservation and old-school engineers (Valverde 2004).

In 1996, the national Ministry of Environment took over the management of the Spanish Network of National Parks. The Doñana National Park was still under the supervision of the Doñana Biological Station, which was mandated to maintain, through its research activities, the stewardship over the Park's conservation. During the 1980s and 1990s, the Andalusian (regional) government engaged in a political and judicial contest to claim the jurisdiction over the Park's planning and management from the Spanish (central) government. After several measures and counter-measures by the Andalusian and central governments (National Parks' Director Plan in 1995, National Parks' Act in 1997, Doñana Nature Reserve Act in 1999), in 2004 the Constitutional Court conceded the right for the management of National Parks to the regional governments. The legacy of the contest for responsibilities over the management of the Park, currently under the stewardship of the Andalusian Ministry of Environment (which changed its name to 'Doñana Nature Reserve'), added a new element of friction to the relationships between the various (national and regional) managing agencies.

The history of the Park was also characterised by contradictory views over the interaction between agricultural developments and nature conservation. With the progressive incorporation of sustainability considerations to the political agenda, these views have often resulted in open discrepancies between institutional levels. For example, the decree passed in 1984 by the central government to substantially reduce the surface initially established for drainage and transformation actually resulted in increased agricultural development on the ground, owing to the application of existing technological advances (see Llamas 1988). In contrast, the hydraulic restoration of the marshes approved in the same decree failed on the ground due to poor definition of objectives, lack of knowledge, legal impediments and technological shortcomings (Casas and Urdiales 1995).

In 1998, the mining accident at Los Frailes contaminated severely and extensively one of the river courses that fed the marshes in the immediate neighbourhood of the Park, the Guadiamar River (see e.g., Meharg et al. 1999). The accident provided the impetus

for the application of two restoration projects, which were implemented separately by the regional (Guadiamar Green Corridor Project, 1998-2002) and national (Doñana 2005 Project, 1998-2006) Ministries of Environment. Both restoration projects were largely based on the established command-and-control paradigm and, in most cases, designed by the engineers that chaired the preceding (drainage and restoration) works. However, enough flexibility for developing new modes of action (e.g., adaptive management, participatory action research) was introduced (Montes 2002, Escalera 2003, Santamaría et al. 2006).

4.3.2. Stakeholder involvement

Following the criteria presented above, I identified a total of 40 actors, of which 34 were finally contacted (the other 6 were either unavailable, retired or on sabbatical; Table 11). 25 were available for interviewing in the first phase (1h on average by the same researcher). Seven took part in the uncertainty workshop, and 24 took part in the research-management workshop (though only 15 participated in the Group Model Building session; see Table 11). All actors (38% decision makers, 62% stakeholders) met our historical criterion, and at least two of Mostert's criteria at one of Ostrom's levels. Decision makers met at least three specific Mostert's criteria (B, C and D) (Table 11). Key decision makers predominantly belonged to agencies with direct management duties over the Doñana Nature Reserve, such as its Administration Office (Regional Ministry of Environment), the Doñana Biological Station (Ministry of Education and Science) and the Guadalquivir River Authority (Ministry of Environment). Stakeholders included officers from the Andalusian Ministry of Environment (Andalusian Water Agency and Nature Reserves Network), academics from national and Andalusian universities and research agencies, and the WWF.

Table 11. Actors identified at the outset of the action-research program

UW = uncertainty workshop; RMW = research-management workshop; DM = decision maker, SH = stakeholder

		Criteria and category						
ID	**Organization**	**Historical**	**Mostert**	**Ostrom**	**Category**	**Interview**	**UW**	**RMW**
A1	Doñana Nature Reserve	Yes	A, B, C, D	A, B, C	DM	Yes	No	Yes
A2	Doñana Nature Reserve	Yes	A, B, C, D	B, C	DM	Yes	No	Yes
A3	Doñana Nature Reserve	Yes	A, B, C, D	B, C	DM	Yes	No	Yes*
A4	Doñana Nature Reserve	Yes	A, B, C, D	B, C	DM	Yes	Yes	No
A5	Doñana Nature Reserve	Yes	A, B	C	SH	No	No	Yes*
A6	Doñana Biological Station	Yes	A, B, C, D	A, B, C	DM	Yes	No	No
A7	Doñana Biological Station	Yes	A, B, C	B, C	DM	No	No	Yes
A8	Doñana Biological Station	Yes	A, B	C	SH	Yes	No	Yes
A9	Doñana Biological Station	Yes	A, B	C	SH	Yes	No	No
A10	Doñana Biological Station and Reserve	Yes	A, B, C, D	B, C	DM	Yes	No	Yes*
A11	Doñana Biological Station	Yes	A, B	C	SH	Yes	No	No
A12	Doñana Biological Station and Reserve	Yes	A, B	C	SH	Yes	No	Yes*
A13	Doñana Biological Station	Yes	A, B, C, D	B, C	DM	Yes	No	No
A14	Doñana Biological Station	Yes	A, B	C	SH	No	No	Yes
A15	Doñana Biological Station	Yes	A, B	C	SH	Yes	Yes	Yes*
A16	Doñana Biological Station	Yes	A, B, C, D	B, C	DM	Yes	No	No
A17	Doñana Biological Station	Yes	A, B	C	SH	Yes	Yes	Yes*
A18	Doñana Biological Station	Yes	A, B	C	SH	No	No	Yes*
A19	Doñana Biological Station	Yes	A, B	C	SH	No	No	Yes*
A20	Doñana Biological Station	Yes	A, B	C	SH	No	No	Yes

Table 11 (cont'd). Actors identified at the outset of the action-research program

UW = uncertainty workshop; RMW = research-management workshop; DM = decision maker, SH = stakeholder

		Criteria and category						
ID	**Organization**	**Historical**	**Mostert**	**Ostrom**	**Category**	**Interview**	**UW**	**RMW**
A21	Guadalquivir River Authority – Water Planning Office	Yes	A, B, C, D	A, B, C	DM	No	Yes	Yes*
A22	Guadalquivir River Authority – Seville Area Office	Yes	A, B, C, D	A, B, C	DM	Yes	Yes	Yes*
A23	Andalusian Water Institute – Doñana 2005 Project	Yes	A, B, C, D	A, B, C	DM	Yes	No	No
A24	Andalusian Water Institute – Doñana 2005 Project	Yes	A, B	B, C	SH	No	Yes	No
A25	Andalusian Water Agency – Doñana 2005 Project	Yes	A, B	B	SH	Yes	No	Yes*
A26	Andalusian Water Agency – Doñana 2005 Project	Yes	A, B	C	SH	Yes	No	No
A27	Andalusian Nature Reserves Network – Directorate General	Yes	A, B, C, D	A, B, C	DM	Yes	No	Yes
A28	University of Seville – Doñana 2005 Project	Yes	A, B	C	SH	Yes	No	Yes*
A29	University of Seville	Yes	A, B	C	SH	Yes	No	Yes
A30	University of Huelva – Doñana 2005 Project	Yes	A, B	C	SH	Yes	No	Yes*
A31	University of Córdoba – Doñana 2005 Project	Yes	A, B	C	SH	Yes	No	No
A32	Polytechnic University of Catalonia – Doñana 2005 Project	Yes	A, B	C	SH	No	No	Yes
A33	Institute for Prospective Technological Studies (European Commission's Joint Research Centre)	Yes	A, B	C	SH	Yes	No	No
A34	WWF/Adena Doñana Office	Yes	A, B, C	A, B	SH	Yes	No	Yes*
-	Mediterranean Institute for Advanced Studies – Doñana 2005 Project [b]	-	-	-	-	-	Yes	-
-	Sierra Nevada Nature Reserve	-	-	-	-	-	-	Yes[a]
Totals	**34** (latter two excluded from count)	**13 DM (38%) and 21 SH (62%)**				**25**	**7**	**24**

[a] Actor that stayed and participated in the third, Group Model Building session of the RMW.

[b] L. Santamaría was invited externally by organiser N. Insendahl to participate in the UW (co-organised with P. F. Méndez), before she joined the action-research program; both then acted as organizers, together with P. F. Méndez and J. Amezaga, in the RMW.

4.3.3. Key outputs from the action-research program

The use of an action-research program allowed us to introduce new modes of actor involvement and to promote collaboratively an understanding of the challenges facing water resources management and wetland conservation in Doñana. In the following paragraphs, I provide the most salient results derived from the program.

At the uncertainty workshop (13th December 2007), the need to take uncertainties into account was made explicit and a reflection process about the approaches required to make such realisation operative was instigated. The workshop showed that there is a considerable variety of uncertainties that actors in water management have to deal with. Their conceptualisation by the different actors was explicitly captured and reflected in a final list of 13 uncertainty situations (Table 12). This exercise (and the derived set of parameters) constituted a first step towards making approaches for dealing with uncertainty more explicit and structured in the case study (see Isendahl et al. 2010 for a more detailed description of the workshop organisation and results).

Our historical assessment indicated that the Doñana's institutional frameworks for water resources management and wetland conservation developed, along history, disparate strategies that currently deepen the conflict between both sectors. This problem was formalised and discussed at the research-management workshop (2nd April 2008). The workshop revealed that the different actors held contrasting mental models about water resources management and wetland conservation. These included different perceptions about nature (nature in static equilibrium vs. constantly-evolving nature) or about the procedures for taking decisions (hierarchically vs. collectively). During the sessions, facilitated through Group Model Building, these differences were made explicit, collectively discussed and accommodated in shared models. Participants were organised in two thematic groups (water and vegetation) and requested to identify first-order and second-order drivers of change towards the accomplishment of a main goal - involving, in both cases, sustainable performance (Table 13, output models are provided in Figs. A4.1 and A4.2 in Appendix 4).

Table 12. Uncertainty situations in Doñana

Upper panel: situations of uncertainty relevant to the professional work of the participants. Lower panel: shared parameters

Situations of uncertainty
1. How to communicate uncertainties to the public?
2. How to set priorities when dealing with several uncertainties?
3. How would the marshlands react to the removal of the dike?
4. What are the socioeconomic consequences of the WRM in the region?
5. What do we know about the natural system (marshlands)?
6. What Doñana/marshlands do we want?
7. What is the security of an economic investment?
8. Have I considered all uncertainties?
9. How does the society react on a management decision? (example Agrio reservoir and question of distribution of water)
10. How does the agricultural sector evolve (e.g. effects of Common Agricultural Policy change)?
11. How do the different interests affect decision-making in management?
12. How to predict the medium recharge of the aquifer?
Shared parameters
1. Capacity to tackle the uncertainties
2. Type of uncertainty/sectoral structure
3. Urgency/Priority to deal with the uncertainties
4. Conceptual clarity/knowledge about the problem or the uncertainty
5. Level of action
6. Recognition of the uncertainty as such by the public
7. Strategy to tackle the uncertainties
8. Capacity to assess the unforeseen consequences of the uncertainty
9. Cause of the uncertainty

Source: Isendahl (2010)

The "water-management group" built a model aimed at achieving "sustainable water management regimes that ensure the long-term conservation of the biodiversity hosted by the Doñana Nature Reserve marsh/wetland ecosystems" (Fig. A4.1), whereas the "vegetation management group" built a model aimed at achieving "the sustainable management of the vegetation of the Doñana Nature Reserve marsh/wetland ecosystems (and its grazers), in order to ensure the conservation of the biodiversity hosted by them" (Fig. A4.2). Participants were asked to identify first-order (directly influencing the main goal) and second-order (directly influencing first-order factors) drivers of change towards the accomplishment of the main goals (see Table 13). Additional goals during the discussions were (1) to work towards a shared understanding of water management and nature conservation in the Doñana region, and (2) to collectively identify options of institutional change. Finally, both groups were asked to identify key sources of uncertainty in the modelled subsystems (water and vegetation), which were contrasted with those reported in the uncertainty workshop.

Table 13. Synthesis of first-order and second-order causes recognised as drivers of change towards the accomplishment of the main goal by the participants in the Group Model Building sessions of the research-management workshop

Session	Main goal	First-order causes	Second-order causes
Water	Sustainable water management regimes that ensure the long-term conservation of the biodiversity hosted by the marshland/wetland ecosystems of the Doñana Nature Reserve	- The improvement of knowledge on ecosystem functioning - The promotion of social dialog in the affected region. - The clear definition of management and conservation criteria (e.g. water quantity and quality needs) - The improvement of inter-agency and trans-disciplinary coordination - The management of the 'Doñana sub-basin'	- The implementation of long-term monitoring programs - The free availability and transfer of results from these programs - The development of standards and technologies for information sharing and transference - Socioeconomic research - Political support (was envisaged as instrumental) for the elaboration of collective, shared management and conservation criteria - Environmental education (driver of change affecting the whole model)
Vegetation	Sustainable management of the vegetation of the marshland/wetland ecosystems of the Doñana Nature Reserve (and its grazers), in order to ensure the conservation of the biodiversity hosted by them	- The adjustment of the herbivore load to the temporal fluctuations and spatial variation in the marsh's carrying capacity - The adequate implementation, on the ground, of the DNR's planning and management instruments - The collective building of a system's functioning model (including hydrologic, climatic and vegetation dynamics) - The introduction of preventive management strategies (e.g. risk management, prevention and control of alien species) - The establishment of water quantity and quality criteria	- The reduction of erosion through hydraulic restoration of streams - The improvement of agricultural planning - The re-evaluation and improvement of the existing legal instruments - Knowledge generation and information gathering through research and monitoring - Environmental education (driver of change affecting the whole model) - Future reforms of EU's policies (e.g., Water Framework Directive, Common Agricultural Policy) (driver of change affecting the whole model)

Uncertainties included gaps in ecological and socioeconomic knowledge, complex ecosystem behaviour, unpredictable reactions of society to management decisions, unexpected political developments (such as changes in EU policies) and climate change. Uncertainties were then scored for importance and urgency. Climate change was scored

as "most worrying" source of uncertainty in both sessions; however, it was not considered the most urgent. Instead, participants assigned the highest priority to actions addressing (1) the lack of knowledge about the hydrological system, and (2) the unpredictable reactions of society to management decisions. Finally, the combined use of thematic talks, facilitated discussion and Group Model Building proved also to be instrumental for the participatory identification of future steps and initiatives towards institutional change in the context of Doñana hydro-ecological restoration projects. The participants agreed on seven key recommendations for the improvement of the research-management interface (see Table 14. See Appendix 5 for a Spanish version of the policy brief produced after the workshop).

Table 14. Key policy recommendations of the participants in the workshop for the improvement of the research-management interface in the Doñana Nature Reserve (DNR)

1.	The transparent definition of shared management goals and functioning models of the DNR's marshland/wetland ecosystems
2.	The structuring of existing monitoring programs, based on established goals and functioning models, and seeking to optimise coordination among agencies
3.	The incorporation of social research and public participation into policy making and management plans
4.	The definition, within the new Management Plan of the Guadalquivir River Basin, of a specific sub-basin for the DNR wetlands and its tributaries. Such a definition would resolve the contradiction inherent to the declaration of most river branches flowing into or surrounding the DNR as highly modified watercourses (therefore free from the obligation of achieving a good ecological status)[26]
5.	The continuation and enhancement of the collaborative dynamics that emerged after the Los Frailes mining accident. These dynamics are broadly perceived as a social good, which should be promoted both politically and economically
6.	The improvement of instruments for information exchange and inter-agency goal definition among the Doñana Nature Reserve, the Doñana Biological Station and the Guadalquivir River Authority. Examples include the development of protocols, standards, joint committees, virtual workspaces and corporate databases for mutual support and joint decision making
7.	The stepwise introduction of learning, novelty and innovation into management, based on the transfer of knowledge generated in well-defined pilot projects and programs (Caracoles)

4.4. Concluding remarks

This chapter has assessed the configuration of the institutional regime for water resources management and wetland conservation of the Doñana Nature Reserve, by

[26] Policy recommendation number 4 of the research-management workshop is compatible with a policy recommendation on water governance from the literature, also produced through participatory workshops involving local decision makers and stakeholders, namely: water should be "the core of management, conceptualising the Doñana social-ecological system inside of its watershed" (see Palomo et al. 2011)

providing a preliminary analysis of its historical development. It has also evaluated the instrumentality of action research for proactively introducing adaptive management tenets at the research-management interface, building trust among stakeholders, facilitating their involvement in the program and producing policy guidance.

Based on the assessments, information and findings reported above, the following concluding remarks can be made:

- The results of the historical institutional assessment pointed to the persistence of institutional rigidities for water resources management and wetland conservation in the Doñana Nature Reserve, in particular, and in the Doñana region, in general.
- In such context, the use of an action-research program based on the assessment of the Canadian institutional experience with adaptive management and the AMBoK, was instrumental in loosening rigid organisational structures in Doñana.
- The action-research program served, in particular, the long-term purpose of proactively engaging the actors directly concerned with decision-making in a joint research-and-learning process, aimed at facilitating future implementations of flexible and innovative approaches such as adaptive management.
- The results of this research stage suggest that any attempt to introduce participatory strategies in rigid institutional configurations must be preceded by preparatory work by agents of change, in order to increase organisational flexibility and involve a wide-range of stakeholders.
- The combination of methods used (interviews, focus groups and Group Model Building in workshops) constituted a powerful tool to identify and develop, informally and collectively, unexpressed ideas that had remained tacit but were broadly accepted, on issues that hinder the potential for the resolution of key problems and broader conflicts (e.g., the existence of large power distances between individuals within and between research and management agencies).
- It is also worth noting that action-research initiatives represent a demanding task requiring updated knowledge about the case study, *in situ* social capital, strong commitment, resilience to short-term failure and considerable social/emotional skills – particularly since those involved in them usually enter a locked conflict as "external insiders", and must navigate the risk of being involuntarily involved in the conflict among the different actors.

The preliminary historical institutional assessment, and in particular the identification or organisational and institutional rigidities in both water resources management and wetland conservation, combined with in-situ observations and insights from the literature, led me to the conjecture of the Doñana region as a case study of 'maladaptive water socio-ecosystem' governed through a 'rigid institutional regime'. In turn, this conjecture led me to the elaboration of hypothesis h_1 about the origins of the institutional rigidity and the maladaptive state of Doñana. Both my conjectures and hypothesis led to the design of the research described in next chapter, aimed at proving the existence of this rigid regime, as well as at understanding and explaining its historical evolution and stabilising mechanisms, through an analysis informed by the theoretical framework of the thesis.

Chapter 5. Historical systems narrative: Doñana, a contingent outcome

5.1. Introduction

Building on the historical institutional assessment of the previous chapter (Section 4.3.1), in this chapter I delve into the origins and characteristics of the conjectured Doñana's 'rigid institutional regime' for water resources management and wetland conservation[27]. This analysis deals with the command-and-control schemes that, in general, pervade traditional policies for water resources management and wetland conservation worldwide. As described in the general introduction of the thesis, the long-term application of command-and-control schemes tends to drive natural resource and social-ecological systems into maladaptive states. Both the recurrence in the application of command-and-control schemes and the institutional rigidity inherent to maladaptive social-ecological systems tend to hinder change and innovation, and favour the mutual reinforcement of power, politics and profit.

The historical institutional assessment performed to inform the action-research program (see Chapter 4, Section 4.3.1), together with in-situ observations during the mentioned program, revealed a rich historical record of application of command-and-control schemes in both the water resources management and the wetland conservation functions in the Doñana region. This realisation, complemented by comparisons with other social-ecological systems (Gunderson et al. 1995, Holling and Meffe 1996, Gunderson and Holling 2002, Allison and Hobbs 2004), led me to the conception of the Doñana region as a case study of 'maladaptive social-ecological system' characterised by the key features of the "pathology of natural resource management", as have been defined in Section 1.1, namely: (1) a highly vulnerable (i.e. low resilient) marshland/wetland ecosystem; (2) institutional rigidity in the water resources

[27] The research described in this chapter has been published in: Méndez, P.F., Isendahl, N., Amezaga, J.M. and Santamaría, L., 2012. Facilitating transitional processes in rigid institutional regimes for water management and wetland conservation: Experience from the Guadalquivir Estuary. Ecology and Society, 17(1), 26. [Online] Available at: http://www.ecologyandsociety.org/vol17/iss1/art26/

management and wetland conservation functions; (3) an origin in the recurrent application of top-down, command-and-control schemes (see also Gómez-Baggethun and Kelemen 2008). Therefore, I turned to an in-depth analysis of the current configuration and historical origins of institutional rigidity and the maladaptive state in the Doñana region.

This chapter, through a first theoretical iteration, provides a historical explanation of the current rigid configuration of the Doñana's regime for water resources management and wetland conservation. The explanation is informed by the following elements of the theoretical framework of the thesis: the Institutional Analysis and Development (IAD) framework, the proposed elements from resilience theory (adaptive cycle heuristic, institutional resilience and maladaptive traps departing from the cycle), and the concept of institutional path dependence. For the general conceptualisation of rigid institutional regimes that I'm evaluating here see Chapter 2, Section 2.3.3. Towards the end of the chapter, a preliminary evaluation of the hypothesis h_1 of the thesis and of the epistemological paradox of contingency is offered.

5.2. Methods

5.2.1. Redesigning the case study

Based on the insight gained along the previous research stages, I refined the design of the case study at a geographical level. In particular, I conceptualised the Doñana region's whole human-wetland-water system as a coupled water socio-ecosystem located within a well-defined area at the right bank of the Guadalquivir Estuary, composed of two parts (Fig. 13). One part was composed by the remaining area of semi-pristine marshland and floodplain wetland ecosystems, protected by the Doñana Nature Reserve; the other, by the surrounding area of irrigation and rice agriculture. The two areas share origins in the Guadalquivir marshlands, which originally stretched over both banks of the estuary.

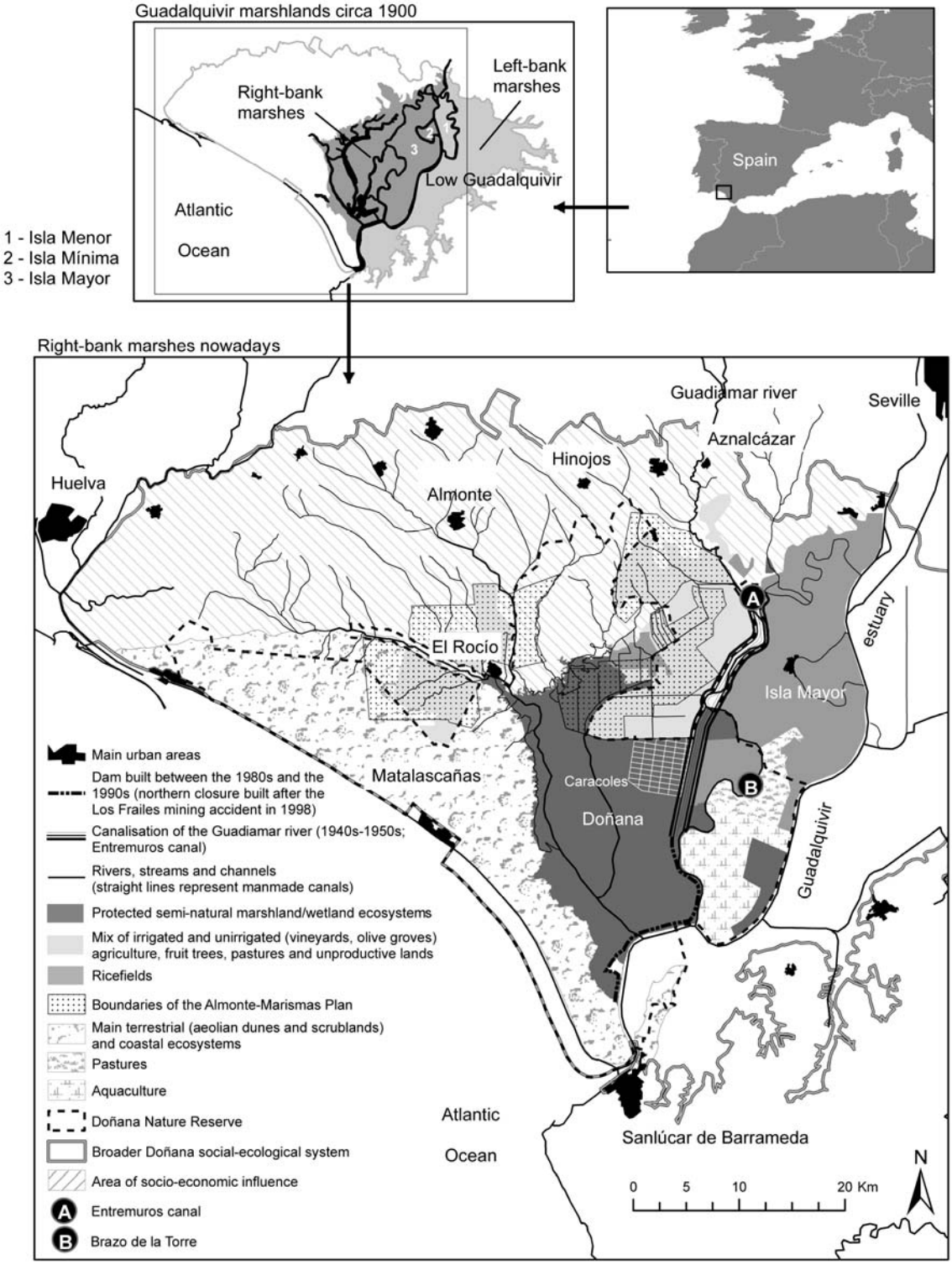

Figure 13. Geographical location of the Doñana water socio-ecosystem

The two areas comprising the Doñana water socio-ecosystem include: (1) the remaining area of semi-pristine marshland and floodplain wetland ecosystems, protected by the Doñana Nature Reserve (dark grey); (2) the surrounding area of irrigation (light grey) and rice agriculture (medium grey). *Source*: my own elaboration from POTAD (2003), Castells et al. (1992, boundaries of the Almonte-Marismas Plan), and Gómez-Baggethun et al. (2012, boundaries of the wider Doñana social-ecological system)

The conceptualisation of Doñana as a water socio-ecosystem[28], which is used in the institutional analysis presented in this chapter and the next one, emphasizes the Doñana Nature Reserve as a core marshland/wetland area surrounded by an area of agricultural predominance, at the right bank. It has two purposes: (1) to emphasise the critical importance of water resources for the purposes of human use and wetland conservation in the region; (2) to develop a manageable unit of analysis allowing, concurrently, for sound institutional research about highly complex problems in Doñana and for facilitating the production of applicable policy guidance in accordance with the normative component of the thesis. The conceptual, embedded case study design applied to this research stage is shown in Figure 14.

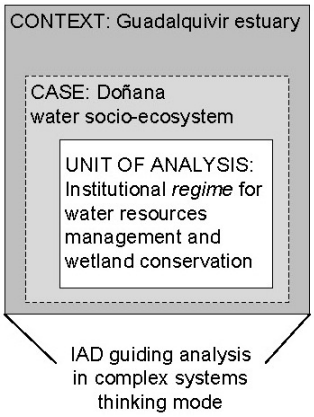

Figure 14. Conceptual design of the case and unit of analysis applied to the first theoretical iteration of the institutional anlysis

Note the shift, as compared to Figure 12 in Chapter 4, from the *Doñana Nature Reserve* to the *Doñana water socio-ecosystem* in the case study, and from institutional *framework* to institutional *regime* in the unit of analysis. *Source*: based on Yin (2009, p. 46).

[28] Note the difference between this conceptualisation and the conceptualisation of Doñana as a wider social-ecological system, whose frontier is delimited by an administrative boundary including both banks of the estuary (see e.g., Palomo et al. 2011, Gómez-Baggethun et al. 2012). In this thesis, I treat the boundaries of both the 'water socio-ecosystem' and the broader 'social-ecological system' as provisional. In my contention, future re-elaborations of such boundaries must consider that both banks are hydraulically disconnected and have had divergent historical trajectories producing distinct outcomes that require different normative treatments.

5.2.2. Historical systems narrative

Building on the preliminary historical institutional assessment of the action-research program, I collected further qualitative historical data which I termed institutional events. As in the previous assessment, data were collected from a number of historic accounts about the Doñana region and about other relevant events affecting the region. Afterwards, I classified and structured the raw data using directed, deductive content analysis (see e.g., Hsieh and Shannon 2005). I used a broad conceptual categorisation matrix, composed of two nominal categories: (1) *key institutions*, (2) *main policy, economic, organisational and scientific-technical features*. These categories were crossed with the *historical period* at which each institutional events took place (based on classical denominations of Spanish historiography; see e.g., Domínguez-Ortiz 2000). The complete data matrix, historical profile and references to the sources of evidence are presented in Appendix 6.

The nominal categories constituted integrative surrogates to both observe the general components of the institutional regime (i.e. institutions, organisations and epistemological domains) and infer the propositional features of command-and-control paradigms that characterize, at a more abstract level of analysis, rigid institutional regimes (e.g., hierarchical decision making, power distance, 'white elephants'; see Chapter 2, Section 2.3.1 above). Data analysis and interpretation was performed through the elaboration of a historical systems narrative (see e.g., Allison and Hobbs 2004), applying the thinking mode and inference procedure described in Chapter 2, Section 2.4. The IAD was applied as described in Figure 15.

Along the elaboration of the historical systems narrative, I complemented the historical profile of the matrix with the identification of corresponding phases of the adaptive cycle (*cycle's phase*). More specifically, I focused on:

- The identification of adaptive-cycle phases fitting the evolution of the water resources management and wetland conservation regimes separately.
- The description of the dynamics of their descriptive properties (potential, connectedness and resilience), with a specific focus on institutional resilience.

- The identification of "critical junctures" and their effects over the historical trajectory of both regimes.
- The identification of maladaptive traps departing from the adaptive cycle.
- The search for proof of path dependence (e.g., self-reinforcing mechanisms), specially with reference to command-and-control, technocratic schemes.
- The qualitative evaluation of h_1.

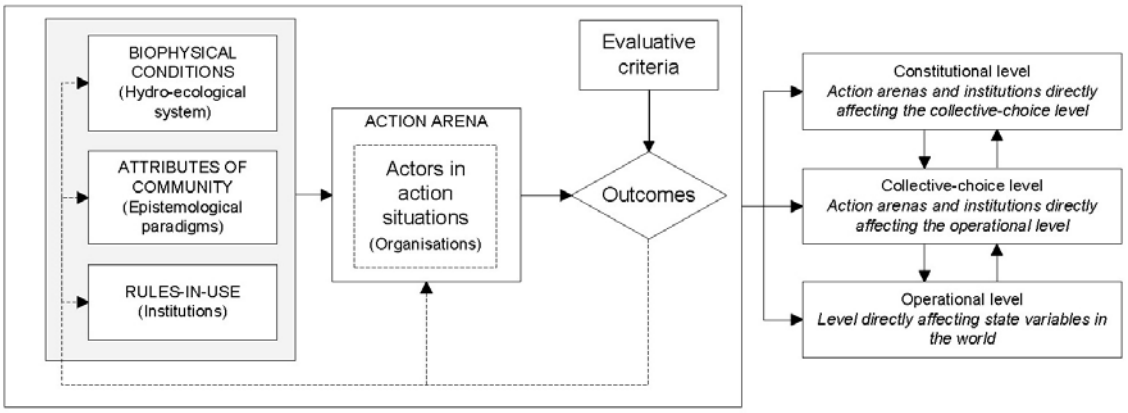

Figure 15. Application of the IAD at this research stage, in complex systems thinking mode

Inferentially, the task consisted in explaining and interpreting how certain past mechanisms have had a causal role in the formation of the outcome conjectured by h_1. Those mechanisms were assumed from the logical expectations and theories (e.g., assumptions, propositions) integrative of both the thesis' conception of resilience theory (adaptive cycle heuristic, institutional resilience and maladaptive traps departing from the cycle) and the IAD, used in complex systems thinking mode. As argued in Chapter 2, Section 2.4 that way of reasoning backwards adjusts to retroduction.

5.3. Results

In the following sections, I First present two separated narratives for the period between the end of the 18th century and 1969, which respectively interpret the foundation and development of the Doñana's institutional regimes for water resources management and wetland conservation. Afterwards, I present a joint narrative for the period 1970-2000, which interprets how both regimes operated separately, but in synchrony, due to their common foundation upon command-and-control institutional schemes (see Fig. 16 for a

diagrammatic representation of the narratives, including examples from the most salient institutional events).

5.3.1. From the end of the 18th century until 1969

5.3.1.1. Water resources management

The intensive transformation of Doñana did not start until the 1920s. However, the roots of its current institutional regime for water resources management can be traced back to the end of the 18th century. At that time, organisational structures for water planning and management in the Guadalquivir Estuary were still based on the implementation of scattered projects for the construction and maintenance of a rudimentary infrastructure for water distribution and use, i.e. on the marginal control of water. Overall, the ruling regime was characterised by a rather stable, self-sufficient and sustainable economy based on local and traditional ecological knowledge, which had limited impacts on the estuary's hydro-ecological system. Such a regime corresponded to the last stages of an r-K phase (Fig. 16, point 1), during which local pioneers (r-strategists) became adapted to external variability, expanded incrementally and accumulated capital from the extraction of water resources, until reaching a stable exploitation pattern in which competition was starting to take place. The ensuing K phase was arranged around an archaic property system and formal institutions empowering the governing nobility (K-strategists) to regulate and organise the use of water resources.

At this stage, the regime showed limited resilience to: (1) the national, enlightened-absolutist socioeconomic trends of the époque, which promoted navigability and economic development in the estuary; and (2) the top-down, constitutional, deficit-driven impositions enforced by State officials. I argue that this was caused by two main mechanisms. On the one hand, internal stability was disturbed from inside, particularly at the operational level, where a number of key private entrepreneurs effectively promoted their view of the entire hydro-ecological system as an underexploited region with enormous potential (i.e. low-released capital). On the other hand, the regime was characterised by a general void of inter-scale, collective-choice action arenas for the cooperative definition of more equitable formal rules for resource use and management (e.g., uniting the governing nobility and the local administrations). This void precluded

the development of interconnected decision making processes and multilevel action arenas within the regime, i.e. it resulted in low connectedness that lowered its institutional resilience.

In system terms, the institutional regime lacked the necessary internal regulation and control for absorbing external disturbances, and was highly sensitive to the free will of some internal entrepreneurs. This resulted in a system-wide institutional collapse (Ω phase; Fig. 16, point 2), after which the entrepreneurs started to target the large-scale modification of the hydro-ecological system, and to progressively restructure the regime around a novel, alternative configuration (α phase; Fig. 16, point 3). The first plans and projects aiming at the transformation of the estuary into navigable watercourses and the marshes into productive cropland were developed. Although they were not implemented immediately in Doñana (e.g., disentitlements were only applied to surrounding scrubland and forest properties), they represented the first organised attempts to turn the region into an economically productive land. This broad event resembles a Schumpeterian phase of "creative destruction" (Schumpeter 1950, p. 83), at the institutional level.

By the mid 19th century, the regime had entered a new r phase (Fig. 16, point 4), characterised by the positive feedback between new constitutional institutions and local events. Royal governments transferred common property rights to actors at lower, collective choice and operational levels, allowing them to dedicate large individual and cooperative efforts to promote the new economic productivity perspectives, from both the public and the private sectors. During the second half of the century, this process was reinforced by new institutions and strategies, including the progressive increase of organised middle class actors and sophisticated technological projects, necessary to tackle the high investment costs and long-term recouping required for the transformation of marshland into irrigated cropland.

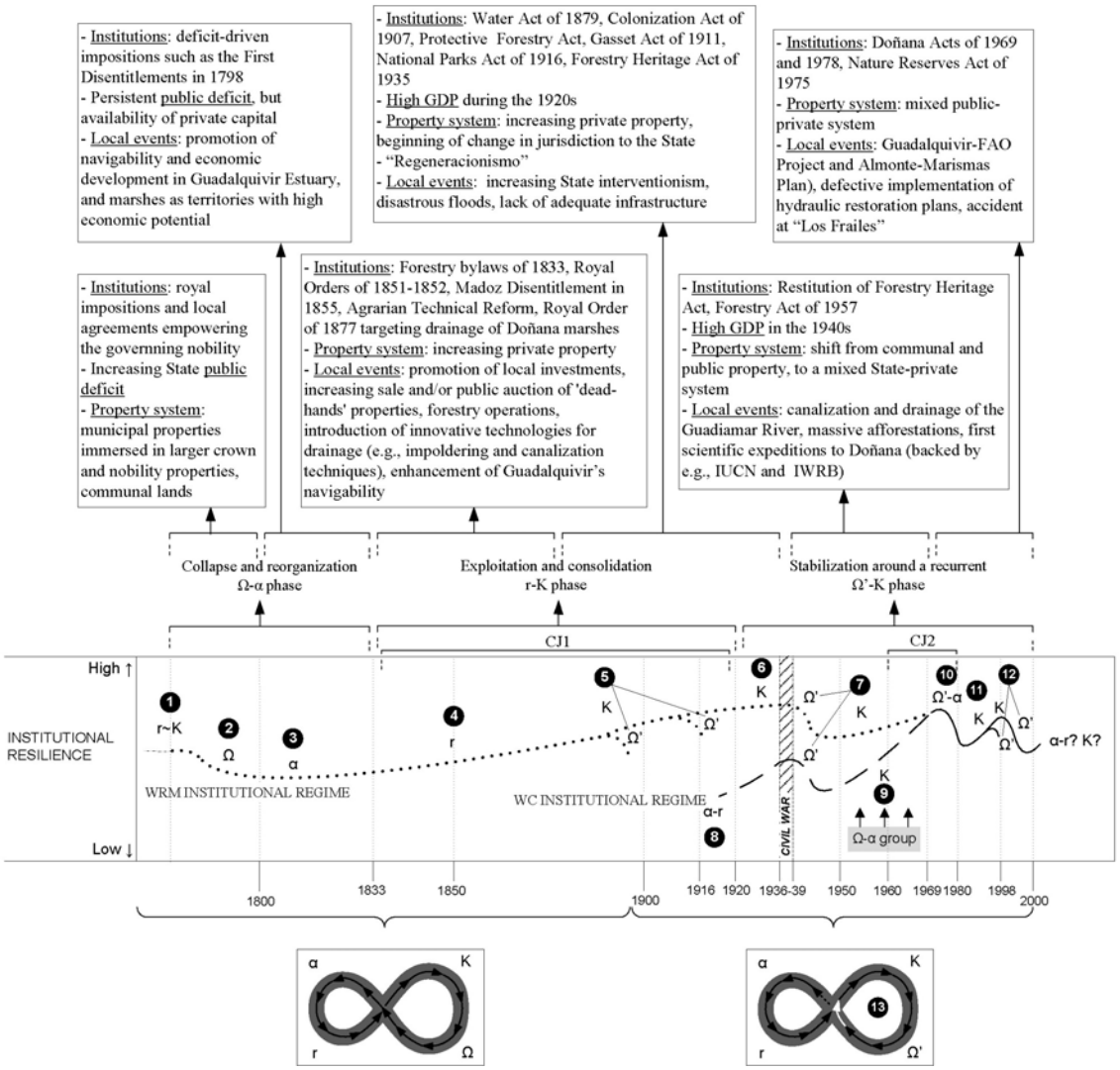

Figure 16. Historical development of Doñana's institutional regimes for water resources management (WRM) and wetland conservation (WC), interpreted through the adaptive cycle heuristic, and concomitant changes in institutional resilience

Black points with numbers refer to dynamics of the phases of the adaptive cycle applied to the Doñana's institutional regimes, described in the main text. Dates and description profiles of institutional events are provided in Appendix 6

At the end of the 19th century and the outset of the 20th, the regime started to stabilise around a K phase (Fig. 16, point 5), with the support of newly formed institutions at the constitutional level and intellectual-scientific movements that encouraged large hydraulic modifications at the national level (the so-called regenerationism movement, from the Spanish "regeneracionismo", see e.g. Orti 1984). During this period, the social and economic costs and risks associated with technological failures did not seem to represent a major limiting factor for actors at the collective-choice and operational levels. For example, the deficiencies in the public infrastructure that defended the

inflowing, canalised rivers in the surroundings of the Doñana marshlands resulted in several floods, characterised as "disastrous", which ravaged the impoldered lands and colonial towns from 1892 to 1916, and broke down new dikes built with private funding in 1927 (Enggass 1968). Dikes were however rebuilt, heightened, and reinforced in the entire area (e.g., by the Guadalquivir Marshes Company for rice cultivation) without a detectable revision of the underlying strategies (Enggass 1968, González-Arteaga 2005). Similarly, projected economic targets for the production of irrigated lands (e.g., cultivation of cereals, commercial crops, and forage) were not met due to lack of adequate infrastructure for reducing soil salinity and draining regularly flooded farmland, compounded by the fragmentary planning and uncoordinated work (Enggass 1968). However, both these targets and the agronomic planning behind them remained uncontested (Enggass 1968, González-Arteaga 2005).

In other words, the recurrent impact of natural disasters and the low economic performance of the production systems did not challenge the existing, on-the-ground approaches for water resources management, owing to the strong institutional support for the implementation of new technologies. Thus Ω phases were not followed by α phases of destructuration and renewal. These phases are indicated as Ω' to emphasise the absence of α phases (Fig. 16, point 5), and the reestablishment of the K phase after them (Fig. 16, point 6). This whole period followed the collapse of the Ancient Regime and coincided with the Spanish Liberal Reform (1833-1870s) and Liberal-State Consolidation (1870s-1920s) periods (see Appendix 6). It can be conceptualised as a broad critical juncture (CJ1, see Fig. 16), characterised by incremental change and the quasi-sequential accumulation of institutional events depicted in Table 15.

The regime-level processes described so far suffered an almost complete collapse (depicted again as a Ω' phase; Fig. 16, point 7) during the Civil War but, immediately after it, recovered momentum swiftly and returned to the pre-existing K phase (Fig. 16, point 7). This phase became further stabilised by a diverse set of reinforcements at the constitutional level, underpinned by institutional legacies from the past that persisted at different levels. For example, during the 1940s, the regime gradually shifted from being based on communal lands and public property, to a mixed public-private system led and controlled by the engineers of the new authoritarian government, who promoted further the drainage-canalization-colonisation strategy established during the previous decades.

Furthermore, in 1944, the Guadalquivir River Authority (a State organisation created in 1927) presented for the first time a coordinated plan for the canalisation and drainage of the Guadiamar River, aimed at halting its discharge into the Doñana marshes. The project had been backed by pre-war institutions (e.g., Gasset Act of 1911) and benefited, at this later time, from the development of existing infrastructure.

Table 15. Main institutional events characterising the critical juncture CJ1

1. Inherited, inter-scale institutional void (between nobility elites and local administrations)
2. Establishment of the bases for the development of local and foreign trade – by enhancing, for example, the navigation in the Guadalquivir River
3. Diversification of and increase in the productivity of communal lands (e.g., establishment of pine-tree plantations for the production of energy, construction material and coal)
4. Allocation of exchange value, mainly to Guadalquivir River's left-bank marshlands (e.g., creation of farmland and related industry around municipal entities)
5. Provision to wealthy, middle-class private actors (r-strategists) of easy access to title deeds of indivisible properties (large estates) and smallholdings, favouring large investments of capital for land purchase and the establishment of a nascent middle class (economic policies for Liberal-State consolidation)
6. Settlement of the contemporary public debt of the Government Treasury (tax policies).
7. Implementation of new public infrastructures and innovative engineering technologies aimed at intensifying production and maximising returns
8. Spanish economy leaving behind a period of decline. All-time records of the GDP during the 1920s

The post-war regime thus resumed the intensive exploitation of the region, and expanded its focus from agriculture and water resources into forest resource policies and institutions, including the development of extensive eucalyptus afforestations aimed at providing raw materials for industry. The development of new drainage projects for agriculture was fuelled by the synergies from other economic sectors that participated in the development processes, the all-time records of the Spanish GDP during the late 1940s, and the nation-wide autarchy imposed by Franco, which emphasised national food security and supply self-sufficiency. In the 1960s and 1970s these developments, described by some authors as a land reclamation process (Engass 1968), favoured the north-to-south colonisation of the Guadalquivir River's right bank territories, including about 2/3 of the Doñana marshes.

In summary, in the period comprised between the 1920s and the 1960s, the institutional regime for water resources management increased its resilience owing to the maintenance of the former production and engineering schemes, the changes in the property system, and the increasing interventionism and bureaucratisation of the State. The regime became fully stabilised in a K phase dominated by K-strategists (Fig. 16, point 7).

5.3.1.2. Wetland conservation

Spain's institutional regime for nature conservation probably has its foundational constitutional event in the passing of the National Parks Act of 1916. Among the various models of conservation available at the time, governmental authorities selected the top-down implementation of a National Parks system. New room emerged for pioneers to fulfil the institutional developments demanded by the new conservation paradigms. An entirely new institutional regime for nature conservation was purposely created and connectedness among officials and pioneer entrepreneurial actors began to increase. During a short, Ω-α-r phase (Fig. 16, point 8) new organisational structures were created and empowered to operate at the national level, taking elements and techniques from the conservation regimes of other Western countries (such as the USA). However, such structures were necessarily subservient to the powerful forestry- and civil-engineering corps, which systematically excluded "unproductive lands" (i.e. marshland/wetland ecosystems) from protection. Thus, conservation figures included mainly forests and hunting preserves, and a few mountainous sites of picturesque interest. The incipient institutional regime for nature conservation became rapidly dominated by policies and operational techniques already in place for the exploitation of forests, game, and fish.

Although the Spanish Civil War halted the development of nature conservation policies (Ω' phase; Fig. 16, point 7), the tandem National Parks/Forestry Policy persisted after it as the preferred operational model at the national level. Following the top-down, constitutional implementation of new institutions (e.g., Forestry Heritage Act of 1941, Forestry Act of 1957), the regime for nature conservation and forest resource management became increasingly bureaucratic and rigid, and focused almost

exclusively on maximising economic returns. Hence, it rapidly entered a K phase (Fig. 16, point 9).

In spite of the strong rigidity characteristic of K-phase institutional configurations, small crises and reorganisation may be triggered by groups of actors, self-organised in coalition networks, which benefit from "windows of opportunity" (Kingdon 1995) to introduce novelty (i.e. small Ω-α phases triggered by Ω-α groups; based on Gunderson et al. 1995, Olsson et al. 2006). This was the case in Doñana. During the 1950s and the 1960s, perhaps due to its early establishment as one of the most important waterfowl reserves in Europe at the end of the 19th century, a growing awareness of the necessity to safeguard the conservation of its marshland/wetland ecosystems built up, at both national and international levels.

A careful analysis of historical events shows that, in parallel to the development of the institutional regime for nature conservation, a small Ω-α group of actors from the scientific sector (e.g., J.A. Valverde, F. Bernis), informally organised at the operational level, became aware of the unstoppable degradation of Doñana's marshland/wetland ecosystem and started an effective lobbying campaign to introduce a new set of protection policies for their conservation (Fig. 16). These policies were not the result of a strategic analysis and decision making in the public policy sector, but the work of a network of private pioneers and strategists who raised ecological awareness at the societal level and triggered new policy formulations (Valverde 2004).

A Ω-α group that succeeds in achieving change and introducing novelty often benefits from key reinforcements by powerful external groups (Gunderson et al. 1995). In Doñana, several international organizations supported the Ω-α group with key knowledge and funding (e.g., the International Union for Conservation of Nature, IUCN, and the International Waterfowl and Wetlands Research Bureau, IWRB). The lobbying and fundraising campaign reached a peak with the constitution of the World Wildlife Fund for Nature (WWF), the acquisition of large areas of marshland and surrounding forests, and the creation of the Doñana Biological Reserve and Doñana Biological Station (Fernández and Pradas 2000b, Valverde 2004). Indeed, the creation of the WWF was an unexpected international repercussion of the local, protection-for-conservation struggle. The Doñana Biological Station received the constitutional

mandate of conducting research and managing the Doñana Biological Reserve, and a sizable portion of the original marshland and dunes were included in the new Doñana National Park (Act of 1969).

5.3.2. From 1970 to 2000

During the 1970s, both regimes entered a new phase, during which novel α-type attempts to harmonise water resources management and wetland conservation took place. In 1978, after the constitutional replacement of Franco's authoritarian government by a democratic one, the new Doñana National Park Act of 1978 (Doñana Act hereafter) established novel operational guidelines for conservation inside and outside the park, demonstrating for the first time, *de jure*, the public interest in the conservation of its aquatic ecosystems. The new institution seemingly laid the foundations for the consolidation of the wetland conservation regime and the collapse of the old water resources management regime. However, the old technocratic organizations, paradigms, and institutions maintained their top-down, command-and-control schemes and their focus on engineering works. Thus, the institutional regime for wetland conservation entered, after this short period (which can be characterised as a Ω'-α phase, Fig. 16, point 10), a stable K phase in close synchrony with the water resources management regime (Fig. 16, point 11).

In my view, this was due to three main mechanisms that coincided with another critical juncture (CJ2, see Fig. 16) during the 1960s-1970s period of progressivism and transition to democracy (see Appendix 6). First, the management-for-conservation institutions and organisational structures were co-opted by the old-fashioned engineering lobby, which dominated the public sector and still endorsed the previous management-for-productivity, command-and-control scheme. During the 1960s, the Forestry Directorate lived a struggle of power between pro-conservation engineers and old-school ones, focused exclusively on economic productivity (Fernández and Pradas 2000a). Pro-conservation engineers received the support of the Doñana Biological Station, but the struggle was dominated by the established, old-school engineering lobby by 1971, when the Forestry Directorate and the Forestry Heritage merged to become the Nature Conservation Institute (ICONA; Fernández and Pradas 2000a). By 1974, J.A. Valverde, the most significant champion of the Doñana's protection-for-

conservation race, was replaced by an old-school engineer as director of the National Park (Valverde 2004).

Second, the Doñana Act consolidated the dominance of the engineering lobby in the management of the National Park. The direction of the National Park and the Biological Reserve were respectively assigned to the ICONA (Ministry of Agriculture) and the Doñana Biological Station (Spanish Research Council, Ministry of Education). Both agencies received separate mandates: ICONA should manage the Park, while the Doñana Biological Station should guarantee scientific research and monitor its conservation. The conservation of the Doñana marshes, therefore, became dependent on the institutional relationships between the Doñana Biological Station and the ICONA, which personalised the existing tensions among conservationists and old-school engineers (Valverde 2004).

Third, this period was characterised by the promotion of intensive development in the immediate surroundings of the National Park, which was clearly at odds with its long-term purpose and objectives. Governmental agencies, supported by a blooming national economy, continued acquiring more territory, draining wetlands and marshes to gain agricultural lands (e.g., rice cultivation; González-Arteaga 2005), and developing irrigation schemes to feed them with both surface and groundwater. As a consequence, the last strides of pristine marshes in the immediate vicinity of the recently created National Park were transformed; the hydraulic system that fed the Park's marshes was drained, diverted, controlled, or canalized; and the Doñana marshes became progressively dependent on a completely artificial water management regime, which has lasted until today (Fig. 17).

During the 1980s and the 1990s, the synchronised K-phase regimes proved their ever-increasing institutional resilience by surviving several Ω'-type crises (Fig. 16, point 12), including:

- The operational crisis caused, in the late 1980s, by the defective design of the Doñana Hydraulic Regeneration Plan, which failed to restore the intended water inflows and left behind inefficient infrastructure ('white elephants', e.g., D-II-1 canal; Casas and Urdiales 1995).

- The ecological, operational and political crisis caused by the recurrence of massive waterfowl mortalities, during the early and mid 1980s ("botulism crises", Amezaga and Santamaría 2000, Fernández-Delgado 2006).
- The ecological, operational and political crisis caused, in 1998, by the accident at Los Frailes metalliferous mine, which contaminated the Guadiamar River and the Doñana Natural and National Parks (Grimalt et al. 1999, García and Marín 2006).

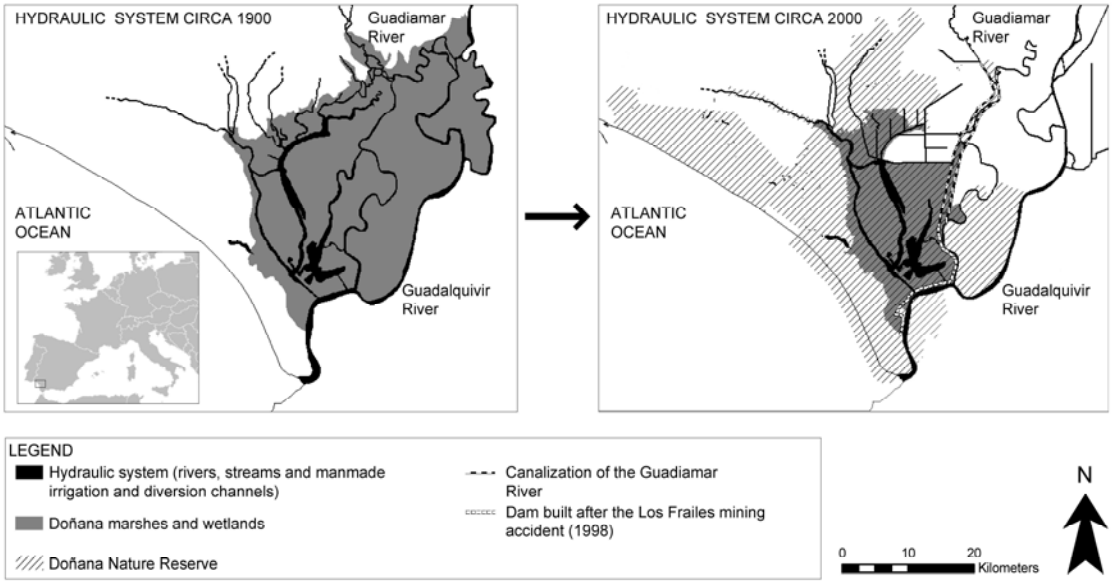

Figure 17. Evolution of Doñana's hydraulic system between 1900 and 2000

None of these crises resulted in the introduction of significant innovative changes within the joint regime for water resources management and wetland conservation, at any institutional level. Paradoxically, they resulted instead in the reinforcement of command-and-control scheme, the increase of the joint regime's institutional resilience and its recursive recycling in a permanent Ω'-K phase (Fig. 16, point 13) that increased further the risk of new social-ecological collapses. Especially relevant is the current hydraulic regime of the remaining marshland/wetland ecosystems protected within the current Doñana Nature Reserve, which largely depends upon artificial management (Fig. 17). For example, water is controlled via a surrounding clay dam equipped with outflow canals and sluice gates, and the flooding regime is halted by early June to prevent waterfowl mortalities triggered by botulism (Casas and Urdiales 1995, Clemente et al. 2004, García and Marín 2006).

5.4. Characterising the outcome

Based on the explanatory pattern provided by the historical systems narrative, I argue that the Doñana's institutional regime for water resources management and wetland conservation can be indeed characterised as rigid. Moreover, based on the theory of maladaptive traps departing from the adaptive cycle, I also argue that the recurrence of command-and-control and the rigid institutional regime has led the water socio-ecosystem to enter a rigidity trap, characterised by a high potential for change, connectedness, and resilience (see attributes in Table 3). More specifically, I argue that this rigid outcome, during the last decades of the 20th century, can be characterised by the following features:

- High stability.
- Top-down, hierarchical decision making and passive public participation processes.
- Reduced opportunity for innovation.
- Highly bureaucratised, rigid, atomised, and internally-focused organizations in which power distance has been promoted.
- An intensively modified hydraulic system sprinkled with inefficient infrastructure.
- A contest of perspectives about the perceived problems, spinning tightly around an economic development vs. nature conservation dichotomy (see also Palomo et al. 2011).
- A highly subsidised economy, based on a few agricultural options (e.g., rice and strawberry cultivation) and continuously threatened by both endogenous (e.g., water shortages) and exogenous factors (e.g., market drift) (González-Arteaga 2005).

The institutional regime for water resources management once fit the adaptive cycle, between the end of the 18th century and the outset of the 19th century. However, since the mid of the 19th century to the present, the institutional regime for water resources management twirled recurrently in a persistent Ω'-K phase; and the emerging regime for wetland conservation was quickly synchronised to this dynamic. Although this recurrence cannot be predicted by the adaptive cycle theory in its simplest form, it can be informed and further characterised by theory on maladaptive traps. Indeed, the outcome configuration of the Doñana water socio-ecosystem seems to fit the features of a rigidity trap.

In Doñana, the institutional regime for water resources management could have stabilised the water socio-ecosystem following CJ1 around three feasible alternative states, namely: (1) a state in which the regime completed, at least, a second adaptive cycle; (2) the chaos trap (high potential, but low connectedness and resilience); (3) the lock-in trap (low potential, but high connectedness and resilience). In the first case, the inference is straightforward: actors learn, after the Ω'-type crises, the long-term inefficiencies of the command-and-control schemes in-use and, instead of promoting institutional reproduction, they foster institutional innovation and restructuring on the basis of the lessons learnt (i.e. Ω phases followed by α phases of destructuration and renewal). In the second case, certain constraints (e.g., the non-existence of public funding, such as in the period prior to CJ1) deprive command-and-control schemes of their initial advantages, which results in a backlash or breakdown of the institutional regime (sensu van der Brugge and Rotmans 2007) and its return to a previous configuration, based for example on a structurally weak and low-resilient, self-sustainable economy. This state fits the features of the chaos trap (see Table 3). In the third case, the regime enters a path in which the whole ecological system becomes irreversibly modified for economic productive purposes, losing its most important ecological and hydraulic components, and posing high sunk costs, i.e. it enters a lock-in trap (see Table 3). The historical systems narrative shows that none of these alternatives crystallised. Instead, the Doñana's institutional regime for water resources management and water socio-ecosystem stabilised around a rigidity trap.

5.5. Preliminary evaluation of h_1 and the paradox of contingency

This section offers a rather abstract evaluation of both hypothesis h_1 and the paradox of contingency, which serves as basis for both the second theoretical iteration presented in Chapter 6 and the general discussion in Chapter 7. On a personal note, I would like to mention that it was the next reasoning which led to a growing interest in delving in the paradox of contingency. Based on the efficiency and productivity baseline of neoclassical economics, hypothesis h_1 can be validated in a fairly straightforward way[29].

[29] Hypothesis h_1 was established as follows: *The historical recurrence of 'command-and-control schemes' is a 'path-dependent process' that has led to the emergence of a 'rigid institutional regime' for water resources management and wetland conservation in the 'Doñana water socio-ecosystem', and caused it to enter and get trapped in a 'maladaptive stable state'.*

I will give reasons to that validation parsimoniously, in order to tackle the paradox of contingency with rigour. On the basis of maladaptive traps theory, the historical systems narrative shows that the historical recurrence of command-and-control and the emergence and persistence of the rigid institutional regime led the Doñana water socio-ecosystem to stabilise in a rigidity trap. The narrative also shows that the current Doñana's rigid institutional regime governing the water socio-ecosystem is characterised by system-wide (institutional, organisational, and epistemological) inefficiency in its current socioeconomic function. Based on path dependence theory and its logical core from neoclassical economics, this overall rigid outcome (rigid institutional regime and rigidity trap) was not a necessary or expected outcome of the preceding events or behaviours that occurred during the first critical juncture (CJ1; Fig. 16, Table 15). Those events and behaviours sought economic efficiency and productivity through the implementation of command-and-control schemes for water resources management (and, more recently in history, for wetland conservation). It can then be postulated that the institutional regime for water resources management was, at a certain point in history, subjected to purportedly random events or behaviours, or more generally, subjected to contingency. These events or behaviours, in turn, can be postulated as having launched the regime through an unpredictable path that diverged from a more expected path of optimal performance. In other words, negative feedback mechanisms steering the regime and actors towards a path-independent, optimal equilibrium, did not seem to operate in Doñana. In sum, the Doñana's rigid outcome represents a path-dependent, inefficient and sub-optimal one that can be qualified as contingent.

5.6. Concluding remarks

This chapter, through the construction of a systems narrative and a first theoretical iteration, has offered a historical explanatory pattern about the current rigid configuration of the Doñana's regime for water resources management and wetland conservation. The findings reported above justify the following concluding remarks:

- The explanation has two distinguishable parts. On one side, the deep-historical genesis of the regime at a critical juncture in the 19th century. On the other, the regime's formation and continuity up to the last decades of the 20th century, despite

its dysfunctionality for coping with crisis and its inability to harmonise wetland conservation, water management and economic development.

- The whole explanation allows to preliminarily evaluating the hypothesis (h_1) that the Doñana's regime has followed a path-dependent dynamic, largely characterised by the historical recurrence on the application of command-and-control policy panaceas.
- In a seeming paradox, these panaceas, instead of driving the regime towards an efficient outcome, led to the formation of a rigid institutional regime that drove the whole water socio-ecosystem into a sub-optimal systemic rigidity trap.
- Through the magnifying lenses of the theory on institutional path dependence, this rigid outcome is qualified by theory as unexpected (i.e. contingent), for it defies the traditional expectations of neoclassical economics that lie at the logical core of the concept of such theory.

Next chapter (Chapter 6), through a second theoretical iteration, turns into an investigation on the role of discourses and entrepreneurship in their relation with politics and power, as factors contributing to the formation of Doñana's rigid outcome.

Chapter 6. The role of discourses and entrepreneurship in their relation with politics and power

6.1. Introduction

This chapter focuses on the following theoretic-analytical question, which evolved and was generalised from the insight gained along the previous stages of the research. In particular, the chapter deals with the explanatory potential of discourses and entrepreneurship in their relation with political-economic interests and power as factors that contributed to shape the rigid outcome of the Doñana water socio-ecosystem. The entrepreneurship factor did not form part of my theoretical framework originally. As I will show, during the analysis presented here, I found it to be a necessary condition to produce the Doñana outcome, as an endogenous mechanism characterising the action of actors in an environment of extreme uncertainty.

The analysis presented here is based on a second theoretical iteration re-examining the historical explanatory pattern developed in the previous chapter and showing how the Doñana's rigid outcome is more predictable. In particular, it shows how predictability can be enhanced if the factors mentioned above (discourses and entrepreneurship in their relation with political-economic interests and power) are taken into the study through more comprehensive analytical frameworks. At a more abstract level, this chapter deals with those factors when the core logic of path dependence, composed by the mainstream principles of neoclassical economics, fail to predict observed outcomes in historical, evolutionary perspective. As has been argued in Chapter 2, Section 2.3.3, when this occurs, such outcomes are qualified as unexpected due to their divergence from purported superior, optimal alternatives, hence subject to contingency. To show that, and by way of preparing a re-evaluation of hypothesis h_1 and the paradox of contingency in the general discussion of the thesis (Chapter 7), I will consistently assess my arguments and lines of reasoning against the baseline principles of neoclassical

economics. Afterwards, in the general discussion of the thesis, I will make the case for the orderly inclusion of the mentioned factors into analysis, so as to systematically inform premature qualifications of historical events or behaviours as proceeding by chance, as random, or, more generally, as contingent. Based on the epistemological paradox created by the notion of contingency, I shall argue that such notion can be modulated away from randomness and better characterised as unpredictability through this type of enriched systematisation.

As has also been argued in Chapter 2, Section 2.3.2, this theoretical iteration was unanticipated. Its carrying out responded to three tightly interrelated, conceptual and practical interests that emerged along the first theoretical iteration. First, it responded to growing interest in delving in the notion of contingency that lies at the heart of institutional path dependence; in particular, in an epistemological paradox that is raised by such notion, loosely tackled in the literature to date (Mahoney 2000). See Section 2.3.3.2 for a detailed description of the paradox. Second, it reflected the criticism raised towards the lack of systematisation into analysis of important contextual factors such as those mentioned above (political, discursive and power factors) in social-ecological research (see e.g., Armitage 2008, Voß and Bornemann 2011, Clement and Amezaga 2013); and more specifically as factors contributing to the historical formation of local social-ecological outcomes. Third, it incorporated recent advancements of a 'politicised' version of the Institutional Analysis and Development framework (the p-IAD; see Clement 2010, Clement and Amezaga 2013). Such framework prescribes the inclusion of the mentioned contextual factors in historical perspective to produce more relevant and comprehensive institutional research, and provides a clear way for organising analysis and produce policy guidance (for recent applications see e.g., Whaley and Weatherhead 2014).

6.2. Methods: Explanation building

The specific method used to analyse and interpret data, and to articulate the second theoretical iteration, was explanation building, an analytic technique based on pattern-matching logic. Explanation building was most adequate to my research due to: (1) its iterative and low-precision narrative nature; (2) its advisability for cases reflecting theoretically significant propositions and insight into policy processes, leading to both

future recommendations about policy action and contributions to theory (Yin 2009, p. 141).

The technique was used to re-examine the historical explanatory pattern developed at the previous research stage (*historical pattern* hereafter) and show how the Doñana's rigid outcome (*outcome* hereafter) is more predictable. The aim was to challenge the *historical pattern*. For that purpose, using the p-IAD (Fig. 18) as the analytical spearhead, an alternative explanatory pattern based on the analysis of discourses in their relationship with politics and power was parsimoniously constructed. During analysis I found the entrepreneurship component to be a necessary condition to produce the Doñana outcome, and added it to the alternative explanatory pattern. The two explanatory (*historical* and alternative) patterns generated were not treated as mutually exclusive. Instead, I expected that the *outcome* was best explained by a combination of both patterns. I assumed the *historical pattern* as the explanation by default. The analytical task was then to determine 'what' each pattern better seemed to explain, hence to capture potential theoretical interdependencies or overlaps, in an explanatory refinement fashion. In fact, I took into account two sets of mechanisms posed by the *historical pattern*, which I failed to see in Chapter 5 as already reducing the unpredictability of the *outcome* (see below). I argue that this responded, to a large extent, to the incompleteness of the theoretical framework used for constructing the mentioned pattern.

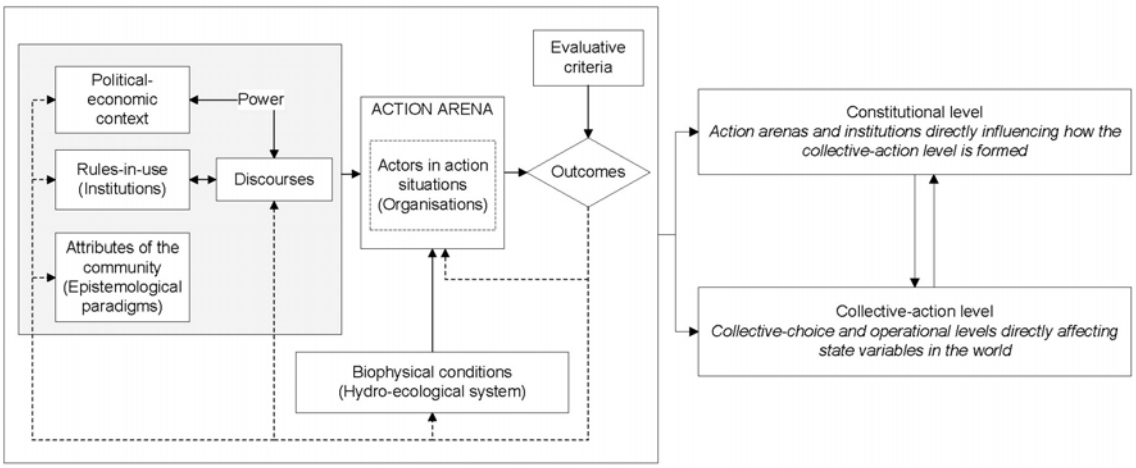

Figure 18. Application of the p-IAD at this research stage, in complex systems thinking mode

In this second theoretical iteration, the inferential task consisted in explaining and interpreting how certain past mechanisms have had a causal role in the formation of the 'observed *outcome*' (as compared to the 'outcome conjectured by h_1'; see Chapter 5, Section 5.2.2). Those mechanisms were assumed from the logical expectations and theories (e.g., assumptions, propositions) integrative of both the thesis' conception of 'institutional path dependence' and the 'p-IAD' (as compared to 'resilience theory' and the 'IAD'; see Chapter 5, Section 5.2.2), used in complex systems thinking mode. As argued in Chapter 2, Section 2.4, this way of reasoning backwards adjusts to retroduction. Although the alternative pattern described in this chapter challenged the findings of the *historical pattern*, it ended up contributing to explanatory refinement, hence improving the prospects for enhanced policy guidance. The conceptual, embedded case study design applied to this research stage is shown in Figure 19.

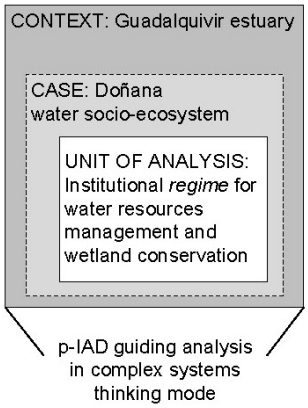

Figure 19. Conceptual design of the case and unit of analysis

Note the shift to the use of the p-IAD, as compared to Figure 14 in Chapter 5
Source: based on Yin (2009, p. 46)

Guided by the levels of analysis proposed by the IAD and, by extension, the p-IAD, I associated political and discursive factors to the constitutional level of action arenas at the state level. Based on previous insights I presumed that, at a historical level, the most relevant institutional and power phenomena associated to such factors have occurred top-down from such tier (see also e.g., Gómez-Baggethun and Kelemen 2008). The collective-choice and operational levels were combined into a single unit labelled 'collective-action', conceptualised as the level directly affecting state variables of the biophysical conditions, in this case, the hydro-ecological system (Fig. 18). This constituted an ad hoc artefact to simplify analysis and discussion, and the process of

informing both the normative component of the thesis and future treatments of the unit of analysis in deeper institutional analyses. Data sources consisted of an enriched, but partial version of the historical profile built in Chapter 5 (see Table 16), through a last round of data collection for the purpose of discourse analysis. That profile included only the period comprised between the Spanish Restoration (1874-1931) and the 1990s (see Table 16).

6.3. Results

6.3.1. Setting the scene of the outcome: a high contingency signal

Prior to my account of results, I shall synthesise the *historical pattern* and set the scene for the *outcome*, with a focus on the high contingency that the latter signals against the static principles of neoclassical economics. I do that based on the comprehensive definition of path dependence as "a property of a stochastic process[30] which obtains under two conditions (contingency and self-reinforcement) and causes lock-in in the absence of exogenous shock" (Vergne and Durand 2010, p. 741). This definition accounts for the genetic, process and outcome abstract elements of the concept. When applied to the *historical pattern*, it produces an alternative but coherent specification of such pattern explicitly sequencing its component parts (Fig. 20), which take root in the critical juncture identified in the previous research (CJ1, Fig. 20, t_1; not analysed in this research stage).

According to the *historical pattern* (Chapter 5), prior to the 19th century, the Guadalquivir marshlands (140,000 ha) were characterised by a subsistence, pre-market economy organised around ancient property arrangements, and farming, fishing and hunting activities, of marginal importance due to the constraints imposed by the harsh and inhospitable environment (e.g., strong flood seasonality, water scarcity for human uses, hard climate, soil salinity, unhealthy conditions and risk of malaria). The marshlands endured, almost unmodified, until the 1920s. However, the first meander cuts and bottom dredging in the estuary (1795-1816), aimed at enhancing navigability and preventing hazardous floods, triggered (Fig. 20, t_{0A}) a multi-level process of policy,

[30] Sensu Vergne and Durand (2010, p. 755): "A stochastic system includes a predictable and a random component. It is non-deterministic".

institutional and strategic change that eventually led to the intensive agricultural and floodplain developments of the second and last thirds of the 20th century (Fig. 20, t_{2A}-t_{3A}). In a first phase, coinciding with the first critical juncture (CJ1) identified by the *historical pattern*, the majority of changes occurred in policy and regulations at the constitutional level, and in strategic, property and organisational re-arrangements among actors at the collective-action level (Fig. 20, t_{1A}- t_{2A}).

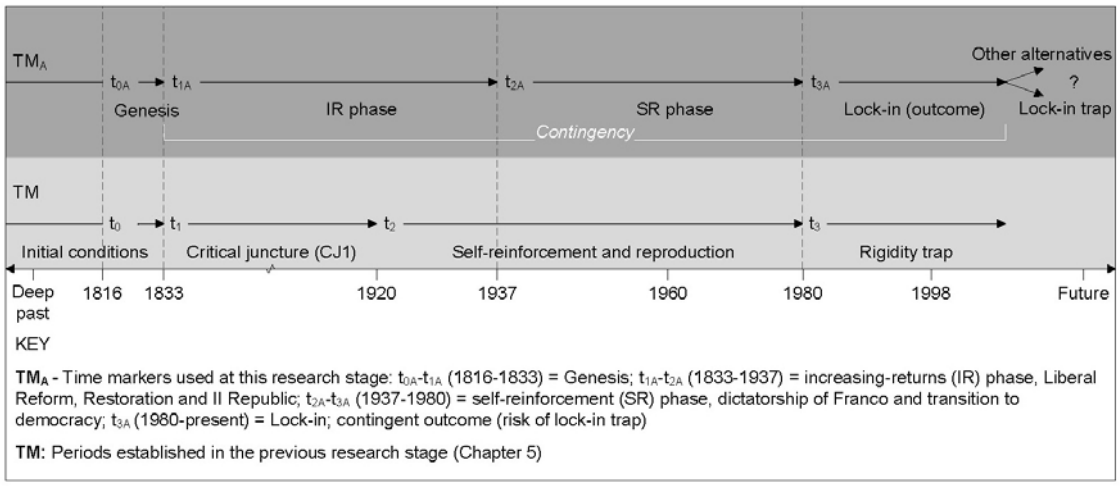

Figure 20. Specification of the *historical pattern* explicitly sequencing its components

Contingency is depicted as a property affecting both the process (e.g., random behaviours or events) and qualifying the final outcome. IR = increasing-returns; SR = self-reinforcement. *Source*: my own elaboration based on the definition of path dependence of Vergne and Durand (2010, p. 741).

During the 1920s and 1930s, until 1937, this process produced significant agronomic outputs in recurrent attempts by private initiatives, rather innovative for the time (Table 16). In a second phase, between 1937 and the 1980s, the process produced changes at multiple regime levels. The most significant was the massive transformation that took place on the ground, in three waves (Fig. 20, t_{2A}- t_{3A}). On the one hand, two concurrent waves of land transformation took place in both the left and right banks of the estuary: one led to the implementation and development of rice agriculture; and the other, which followed closely, led to the development of irrigation agriculture. On the other hand, an inward-outward protection-for-conservation race of the Doñana marshlands and wetlands, as a reaction to the outward-inward agricultural process at the right bank.

For reasons that will become evident, I termed the two described phases as increasing-returns phase (up to 1937) and self-reinforcement phase (1937-1980s), respectively (Fig. 20). At this point, it is worth noting again that my focus is on the developments of rice and irrigation agriculture, and the protection-for-conservation race of the remaining Doñana marshlands, at the right bank (Fig. 13 in Chapter 5), including the marshes of El Rocío, Almonte, Aznalcázar, Hinojos and Doñana. Rice agriculture developed over both banks of the estuary, in particular, over three of the main islands that the river formed in the estuary (northern part of Isla Mayor and Isla Mínima, right bank; Isla Menor, left bank) and the northern part of the area known as Low Guadalquivir (left bank). However, the left bank has followed a divergent historical trajectory producing a distinct outcome, which requires a different normative treatment that is not dealt with in this thesis.

In general, the transformational process along the mentioned phases yielded a large-scale, progressive implementation of techniques, technologies and engineering works on the ground for reducing the natural variation in the estuary and its floodplain marshlands, i.e. for the command-and-control of the biophysical conditions and water resources. This sought to decrease complexity and uncertainty, in order maximise agricultural production, inland water shipping, and returns on investments over the short-term. However, although the second half of the 20th century witnessed large agricultural transformations and the emergence of a highly productive and technically efficient rice sector, the process signals a high contingency against the static principles of neoclassical economics based on two encompassing grounds, corresponding with the increasing-returns phase and the self-reinforcement phase:

1. The majority of the first agricultural attempts along the increasing-returns phase repetitively ended in productivity, infrastructural or financial failures (see Table 16; Enggass 1968, González-Arteaga 2005). A priori, this might indicate either that informational, negative feedback mechanisms did not operate efficiently at any point to make actors react and readjust their approaches in subsequent enterprises, or that actors were subject to random, irrational behaviour.

2. The full development of both rice and irrigation agriculture in the Guadalquivir marshlands along the self-reinforcement phase appears as illogical for several reasons that I develop below, focusing first in rice agriculture (Section 6.3.1.1) and, then, in irrigation agriculture (Section 6.3.1.2).

6.3.1.1. Rice agriculture

Regarding rice agriculture, there are two broad unfavourable biophysical features of the estuary and the marshlands that create a severe salinity problem posing economic barriers very difficult to overcome. The intrinsic salinity of the phreatic zone and the marlstone-clayey soils of the marshlands, which have marine origins and acted as a swampy endorheic basin for hundreds of years (Enggass 1968), results in moderate to high salinities that increase from 0.27 to 141.37 g/L following a broad NW-SE gradient (Grande-Covián 1977, Corominas 1995, Santamaría et al. 1996). In summer, when there is a shortage of precipitation and evaporation is high, the water table of the phreatic zone rise and form salt deposits in the uplands, and water accumulated in the lowlands leave behind thick saline crusts in the dried-up soils (González-Arteaga 2005, pp. 19-26). This occurs in synergy with the high imperviousness of the soils and with the horizontality of the marshlands, which prevent the regular washout of salts and fine elements (Enggass 1968). Moreover, the low slope of the ground along the last stretch of the estuary and the geomorphology of the mouth of the river combine to slow down the velocity of water and allow the tidal ebb to penetrate up to 90-100 km inland, where it stops due to the presence of the sluice-gates dam of Alcalá del Río, built in 1930 (Enggass 1968, Blomquist et al. 2005). To make it worse, the river discharges into the ocean through a single channel that allows a greater penetration of the salinity wedge[31] (González-Arteaga 2005, pp. 19-26). These broad conditions are further compounded by the strongly seasonal temperature and rainfall regimes characteristic of a sub-humid Mediterranean climate, by within-year flow deficiencies for irrigation and by multi-year droughts that create more prolonged water deficits (Parry et al. 2012), thus augmenting water supply and salinity problems.

[31] The length, concentrations, and movements of the salinity wedge depend on the oscillations of both daily tides and seasonal freshwater flows (Blomquist et al. 2005).

Table 16. Historical profile showing key elements of the institutional regime

Period	Date	Element of the institutional regime (legislation, plan, organisation)
Restoration (1874-1931)	1870[a]	*Royal Order*, promoting drainage engineering projects at the Lebrija marshes (left-bank). Most of them finished in 1928, due to inadequate planning and the priority given to navigation policies.
	1870	*Canals and Reservoirs Act*, granting large public-works companies perpetuity rights on the use of infrastructures in which they had invested.
	1877	*Public Works Act*, conceiving Hydraulic Plans as a centralisation instrument, but also laying the foundations for sectoral and secondary legislation incentivising the private initiative through the Concession/Contract of Public Works. Wetlands drainage perceived as a cleaning and public health task.
	1877	*Royal Order*, granting the first large-scale drainage works at the Gallega marsh (Aznalcázar; failed and reinstated in 1910) and the marshes of Almonte (not executed), both at the right bank. Projects justified on agricultural development and the fight against the harmful effects of swampy areas.
	1878	*Royal Order (leprosy RO)*, wetlands as a source of disease and unhealthy areas.
	1879	*Water Act*, giving priority to irrigation agriculture through public intervention, over navigation, at the State level – end of laissez-faire policies. Already marked by regenerationist ideas. Recognition of the principle of subsidiarity. Declaration of surface water as a public good. Distinction between continental (e.g., lakes, lagoons; public property) and coastal waters (e.g., marshes, marshy lands; private property). Consideration of few options for water allocation, the most important being drinking water –"agua de boca"–, agricultural and industrial (agricultural mills and sawmills). Decision about the advisability of transformation entrusted to private owners, except when area declared unhealthy by public authorities, which subsequently incentivised transformation (e.g., subsidies, transfer of property or exploitation rights, fiscal exemptions).
	1880s	Emergence of the *hydraulic-irrigation regenerationist discourse* (HIR discourse).
	1883	*Irrigation Act (Gamazo Act)*, continuing the legislative trend of the Water Acts of 1866 and 1879. Regenerationist.
	1899	*Draft of General Plan of Reservoirs and Irrigation Canals*, precursor of the plan of 1902. Backed by the Civil Engineering Corps.
	1901	Creation of the *Hydrologic-Forestry Service* and the *Hydraulic Works Divisions*, precursors of the Water Authorities (1926). In charge of the elaboration of the plan of 1902.
	1902	*General Plan of Irrigation Canals and Reservoirs* (GPICR, plan of Rafael Gasset, revised in 1909, 1916 –second Gasset plan–, 1919 and 1922, reducing substantially the initial plan in terms of total irrigable surface). Included novel knowledge about Spanish geography and hydrography, complemented the newly created Hydrologic-Forestry Service, and promoted State interventionism. Elaborated by a team of civil engineers, directed by Rafael Gasset (Ministry of Agriculture, Industry, Trade and Public Works), during more than two years, based upon more than 300 reports elaborated by the Hydraulic Works Divisions. Planning the conversion into irrigable lands of more than 1,460,000 ha (6% of the total Spanish territory, 296 hydraulics works listed as advisable). Despite its provisional character, it was in force until the creation of the Hydrographic Union Confederations (1926).
	1907	*Inner Colonisation and Repopulation Act*, halting emigration and promoting the cultivation of low-yield lands. Creation of the Institute of Social Reform.

Table 16 (cont'd). Historical profile showing key elements of the institutional regime

Period	Date	Element of the institutional regime (legislation, plan, organisation)
	1911	*Irrigation of Large Areas Act* (Gasset Act), establishing the State as the financer and promoter of large public works. Legislative protection of the plan of 1902. Synergy with the hydro-electric sector, which continued all along the dictatorship of Primo de Rivera and the II Republic. In 1912 there was an extension of aids for large irrigation infrastructures (e.g., special exemptions – "franquicias especiales").
	1918	*Act for the Drainage of Lagoons, Marshes and Marshy Areas* (Cambó Act), authorising the transformation of unproductive lands. Empowerment of regenerationist policies in the primary sector. Included an extensive typology of marshlands and wetlands. Minimum surface liable to be transformed: 100 ha. Large diversity of financial instruments, tax reductions and transfer rights for both public and private actors. Not mandatory to justify investments upon cleaning and purification purposes.
	1921-1937	Several attempts by private companies, backed by international investment funds and authorised by regulations, to transform the marshes for farming and agricultural purposes, for example: *Guadalquivir Marshes Company* (Guadalquivir marshes, 1921); *Guadalquivir Islands Company PLC* vulgarly known as "the company of the Englishmen", with English and Swiss capital (Isla Mayor, marshes of Aznalcázar and Isla Mínima, right bank, 1926); *Company for the Valuation of the Marshes PLC* with Argentinean capital (1932); *Isla Mayor of Guadalquivir Company PLC* (Gallega marsh, right bank, 1934). Attempts were mostly driven by speculation on the potential of the marshlands for agriculture and in some cases produced high yields, but ended in broad financial and technical failure due to: low profitability of crops in saline soils, fragmentary planning and lack of coordination, and underestimation of damages produced by seasonal natural flooding (e.g., construction of a superficial drainage system incapable of protect agricultural lands) and the harshness of the saline soils (e.g., failure to bring in enough water to effectively washout salts).
	1926	Creation of the *Water Union Confederations*, the modern water authorities.
	1927	Creation of the *Guadalquivir River Authority.*
	1929	*General Plan of Public Works of the Guadalquivir Water Union Confederation*, operative until the 1970s. Emphasis on the need to regulate and streamline irrigation activities all over the basin, through reservoir control.
	1930	*Plan for the Expansion of Irrigation in the Low Guadalquivir* (122,750 ha).
II Republic (1931-1939)	1932	*Agrarian Reform Act,* banning land owners from expelling land tenants from rented lands. Obligation to cultivate, in order to avoid confiscation. Creation of the Institute of Agrarian Reform.
	1932	*Irrigation Act*, increasing the State responsibilities in the development of secondary and complementary public works, in order to realise the functioning of the areas already transformed into irrigable lands.
	1933	*National Plan of Hydraulic Works* (plan of Lorenzo Pardo), authorised by the Irrigation Act of 1932. Elaborated by the General Directorate of Hydraulic Works, through the creation of a Centre for Hydrographic Studies. The main goal was the correction of the "hydrologic imbalance" of the Iberian Peninsula, with a focus on the south-western ("Levante") territories, whose soils were considered to be productive enough to increase agricultural exports. The need for large water diversions ("trasvases") became institutionalised.
	1937-1939	First small-scale successes in rice cultivation in "Isla Mayor" and "Isla Mínima" (right bank) by the company of Rafael Beca.

Table 16 (cont'd). Historical profile showing key elements of the institutional regime

Period	Date	Element of the institutional regime (legislation, plan, organisation)
Dictatorship of Franco (1939-1975)	1939-1949	Battery of regulations further protecting the traditional colonisation-and-development strategy of the state. 1939 – *Colonisation of Large Areas Act*. Creation of the National Institute of Colonisation. Drainage and transformation of wetlands collaboratively planned and executed between the National Institute of Colonisation and private initiatives. Complemented in 1946 by the *Local Colonisations of Interest and Forceful Expropriation of Rustic Property Act.*
	1939	*National Plan of Hydraulic Works* (NPHW, plan of Alfonso Peña), operative until 1963. Synthesised the main principles of the plan of 1933. Complemented by the previous Colonisation Act and by another providing aids for irrigation.
	1940	Declaration of the Guadalquivir marshes as being of *National Interest* by the National Institute of Colonisation. Socioeconomic orientation of the already polderised land (left bank) towards irrigated agriculture.
	1940s	First large-scale successes in rice cultivation by the company *Rafael Beca & Co, Agricultural Industries PLC.*
	1940-1951	Construction of the *Low Guadalquivir Canal*, declared of National interest, in order to irrigate the left-bank marshes. Key in the washing of salts from the land, but of no practical use and considered as "dead", at the time of construction, over a stretch beyond a point 80 km downstream of its beginning, owing to its malfunction in water transport and distribution. It currently forms part of the (more functional) irrigation system of the Low Guadalquivir area (left-bank marshes, 65,000 ha; see Fig. 13)
	1944-1960s	1944-1956 – Canalisation and diversion, by *Rafael Beca & Co, Agricultural Industries PLC*, of two of the main channels inflowing into the right-bank marshes: Guadiamar channel, through the Entremuros canal (1km wide; Fig. 13, point A), and Brazo de la Torre (Fig. 13, point B). The former is currently connected to the second, a dead arm-river that drains to the Guadalquivir Estuary. Construction of about 100 km of dikes and drains. Protection of 20,000 ha of pastures. The works were supported by the Guadalquivir River Authority and backed by the Gasset Act of 1911. In the 1960s, a dam transverse to Entremuros, towards El Rocío was constructed, which currently constitutes the northern limit of the Doñana Nature Reserve. Most of these works were executed by public contract and publicly funded.
	1949	*Colonisation and Property Distribution of Irrigable Areas Act*, prompting the transformation of vast areas. Transformation decided, financed and executed by the state. Continual of the Acts of 1939 and 1946.
	1955	Declaration of the left-bank marshes of *National Interest*. 65,000 ha (33,000 ha of marshes; 32,000 ha of sands).
	1953	*Improvable Estates Act*, classifying large estates either into "improvable" or "model" farms. Classification into "improvable" farm required owners to carry out improvements on pain of compulsory acquisition by the government, in order to increase productivity and qualify such farms as "model".
	1960	*Irrigation Plan of the Low Guadalquivir* (55,000 ha). Construction of a drainage network in the North of Section III (left-bank).

Table 16 (cont'd). Historical profile showing key elements of the institutional regime

Period	Date	Element of the institutional regime (legislation, plan, organisation)
	1965-1971	*Guadalquivir-FAO Project*, in the Guadalquivir River basin by the Spanish Ministries of Industry, Agriculture and Public Works (IGME, IRYDA), with the technical and financial support of FAO. Realisation of a hydrological study and discovery of an aquifer suitable for irrigation, located, in part, below the right-bank marshes of Almonte, Hinojos and Aznalcázar (5-14 m deep; 7,000 hm^3). Since then, it has been subjected to increasing exploitation pressures. Backed by the FAO-Guadalquivir project and the experiences of the left-bank, realisation of a second hydrological study affecting 23,589 ha, declared of National Interest in 1971. Of these, 6,132 ha were included in a plan for the transformation of the marshes of Almonte, Hinojos and Aznalcázar into irrigated agricultural land (*Almonte-Marismas Plan*).
Transition to democracy (1975-1982)	1983	*Water Act*, subordinating large water diversions to specific legislation and to future Hydrologic Plans, and creating the opportunity for an open water market. Inclusion of underground water in the Hydraulic Public Domain.
1990s	1993	First draft of a *Hydrologic Plan* at the national level promoting a new 'hydrological paradigm' (water supply management) in the 1990s, which nevertheless waxed lyrical over the regenerationist dream of Joaquín Costa and kept a hydraulic mark in its promotion of large water diversions.

Sources: own elaboration based on the primary and secondary sources used, and on the historical profile elaborated in the previous research stage (see Appendix 6). Apart from those cited in the main text, other secondary sources included: Andrés-Gallego (1981), Bartolomé (2011), Bayán and Dolz (1995), Ceballos (2001), Gil (2002), Liceras (1987).

From the short-term-maximisation standpoint of neoclassical economics, these biophysical features, in combination, made the economic development based on agricultural transformation of the self-reinforcement phase a counterintuitive endeavour. This is based on the following reasoning, complemented by the counterfactual made in next paragraph. It is true that, although the topographical and climatic conditions of the marshlands potentially matched the needs of several crops, rice was the only crop that was the most adapted alternative to the harsh saline conditions (Sumpsi 1980, Moral-Ituarte 1993, Portero et al. 2007, Muñoz 2009). However, that was a long-term lesson learned after decades of speculation and experimentation, i.e. after a long-term process that does not fit well with neoclassical logic.

It is also truth that the rice sector was in full operation by the 1980s-1990s, and became one of the most advanced in the world at a technical level (34,900 ha, 35% of the marshlands; Portero et al. 2007, p. 16). Indeed, by the 1990s-2000s, it constituted the livelihood of more than 6000 families, and yielded between 262,000 and 342,000 TPY in normal rainfall years. This meant, in unit yields, about 7.5-10 TPY/ha, which doubled the average global yields and constituted 10-15% of the EU average production (based

on Castroviejo 1993, p. 70, Moral-Ituarte 1993, pp. 208,218, Corominas 1995, p. 68, González-Arteaga 2005, p. 64, Portero et al. 2007, p. 19). In sum, the cultivation of rice in the 1980s was already well adapted to the territory and generating significant agronomic yield and economic gain, in an arguable regime of constant returns to scale[32]. However, the salinity problem and the availability of water for irrigation have recurrently challenged (and still does today) its viability and profitability from the outset. Rice, which must be cultivated during spring-summer due to its mild temperature requirements, demands huge freshwater resources to get the optimum salinity level allowing for normal growth (<0.8 g/L, upper tolerance threshold 1.5-2 g/L) (Corominas 1995, p. 68, González-Arteaga 2005, p. 26, Muñoz 2009, p. 140). Water demand, estimated nowadays at a volume of 10,000-12,000 m^3/ha (8,000-9,000 m^3/ha if recycling processes are taken into account), has been traditionally met by resources collected from the Guadalquivir River and the local aquifer through pumping systems, complemented with urban waste effluents, and managed through a complex and costly system of sluice gates and canals (Castells et al. 1992, p. 18, Moral-Ituarte 1993, p. 211, Portero 2001, Blomquist et al. 2005, Muñoz 2009). To ensure this volume of freshwater, the Alcalá del Río dam plays a fundamental role necessary for the regulation of the salinity wedge through planned water discharges[33].

So here is the counterfactual, which is useful and informative to the reasoning, thinking in the primary hydraulic infrastructure needed to collect and distribute water, and transform several thousand hectares of "saline desert" into productive irrigated

[32] Sumpsi (1980) argues that maximum profitability of rice production was reached between 1948 and 1955, and then started to decline until a minimum level was reached by the end of the 1960s. At a structural level, Moral-Ituarte (1991, p. 519) documented a "saturation", from the 1960s onwards, in the hydraulic intervention at the level of the Guadalquivir River basin, related to an increased awareness of an emerging imbalance between water supply and demand.

[33] In the 1980s, flow rates lower than 40m^3/s in the "Alcalá del Río" dam would cause salinity to reach 20 g/L at 9-15 km upstream of the mouth of the river, beyond which a clear and marked seawater-freshwater transition and salinity gradient was established (the so-called "tapón salino"). To meet the salinity levels at 0.8 and 1 g/L at the irrigation intake mains (50-75 km upstream of the mouth of the river), flow should reach 25m^3/s and 30-35 m^3/s, respectively. In the 2000s, the total allocation of resources required for rice cultivation has been estimated at 470 hm^3 (300 hm^3 for irrigation; 170 hm^3 for the regulation of salinity in the estuary). Nevertheless, in drought years the salinity problem has been impossible to overcome. This happened several years in the 1980s and the 1990s, when flow rates higher than 40m^3/s became exceptional and maximum salinity levels were surpassed, making rice cultivation unviable these same years (based on Moral-Ituarte 1993, pp. 208-213, Corominas 1995, p. 68, Blomquist et al. 2005, p. 10, González-Arteaga 2005, pp. 19-26, Portero et al. 2007, p. 19, Muñoz 2009, p. 137).

croplands[34]. What if such infrastructure hadn't been constructed by the 1950s, when the growth of the rice sector commenced at a relevant rate (see Section 6.3.2.2 below)? What if a large part of such infrastructure hadn't been publicly backed (e.g., through top-down coercive changes in the property system, public investments, strong legal and tax incentives) (see Table 16)? The enormous requirement of resources (time, financial and human) for its setup and maintenance would suffice to cast reasonable doubts over realistic short-term returns on investments solely from private financial sources (i.e. with no external aid such as public investments, or distortions, the crux of the matter of the neoclassical paradigm). It is hard to imagine that any idealised neoclassical actor at t_{2A} (Fig. 20), knowledgeable of the failures of the increasing-returns phase (see above) and of the enormous difficulties at the beginning of the self-reinforcement phase, and in the absence of hydraulic infrastructure for irrigation and salinity regulation, would have made a rational decision (of neoclassical type) towards any type of efficient allocation of resources, seeking the transformation of the marshlands into agricultural land, hence a profitable investment.

In fact, the transformational processes were only possible owing to the intervention of the state in infrastructure development and large capitalist companies with high capacity for technological development, but subsidised by the former (Moral-Ituarte 1993, p. 206, Ojeda-Rivera and Moral-Ituarte 2004, p. 31). Today, thorough calculations remain undone, but rough estimates indicate that the total investment in irrigation hydraulic infrastructure in the whole basin, undertaken by the Guadalquivir River Authority between 1939 and 1987, came to Pts 197,000 million[35] (Moral-Ituarte 1991, p. 512). And we must not forget that official information do not include the wages that should have been paid, but were "saved" through the use of slave work for the largest constructions of the 1940s (e.g., Low Guadalquivir Canal, Table 16), which were built by prisoners of war (Moral-Ituarte 1991, p. 508, Muñoz 2007, p. 150). At a more general level, such neoclassical actor could not have envisioned a rice sector highly competitive in the market, since, ceteris paribus (e.g., energy and water prices, market and surplus regulations, external financial inputs such as subsidies), the Guadalquivir

[34] "Reclaiming the land for cultivation would involve these processes: preventing the inflow of outside waters, draining off the precipitation falling into the impoldered zone, and lowering the ground-water table" (Grande-Covián 1960, cited in Enggass 1968, p. 128).
[35] Roughly €5,137 million (estimated using the general inflation Consumer Price Index provided by the Spanish National Institute of Statistics for November, 2013, CPI=433.9%).

sector would have been outcompeted by other regions not limited by water availability. In fact, in pure market terms, the Guadalquivir rice sector is arguably of limited overall economic efficiency outside the European Union's protectionist scheme (based on Castells et al. 1992, Moral-Ituarte 1993, González-Arteaga 2005, Portero et al. 2007).

6.3.1.2. Irrigation agriculture

Against all the odds, from a neoclassical-economics theory standpoint, is the process for developing irrigation agriculture at the right bank with the support of FAO (Almonte-Marismas Plan, affecting the marshlands of Hinojos, Aznalcázar, and Almonte, the latter remaining untransformed; see Table 16). This process epitomises the antithesis of such theory, for two main reasons. First, the experiences of the left-bank transformational process show that the recovery of saline soils required a publicly-funded, long-term costly process of underground drainage that considerably reduced the prospects for short-term economic profitability. Second, there were a lack of: (1) technical training and low specialisation among the local farmers, hence the skills necessary to undertake the planned, high-risk intensive agriculture; (2) the needed financial structure and commercialisation capacity to optimise the benefits from the crops and related agricultural products. This eventually contributed to a deep economic crisis in the 1990s that made it necessary the intervention of the Andalusian, regional government (Rubio-Recio 1977, p. 280, Castells et al. 1992, p. 14, Rubio-Recio 1993, p. 62, Corominas 1995, pp. 69-71).

The total cost of the drainage system through canals, underground pipes and water pumps is still uncertain, but would surely result nowadays in an negative assessment of the (lack of) economic success of a project that was forcefully dissuaded by the World Bank as early as 1962 (Rubio-Recio 1993, p. 62). Calculations from 1992 estimated the total costs of the agricultural transformation (15,000 ha) at Pts 55,000 million, the private family debt at more than Pts 2,300 million, and the economic viability plan to overcome crisis at Pts 1,500-1,700 million[36] (Castells et al. 1992, Castroviejo 1993). Furthermore, the top-down implementation of this initiative was immediately preceded by the declaration of the Doñana National Park in the south and the declaration of part

[36] Roughly €292.5, €12.23 and €7.98-9.04 million, respectively (same calculation as above; CPI=88.5%).

of the southern coast of the region as of 'national interest', in order to promote urbanisation and tourism. The uncoordinated, authoritative implementation of these three initiatives, which responded to general, but conflicting goals and interests, and wasn't paralleled by public participation and stakeholder involvement processes, constituted a deep source of mistrust and discontent from the local population (Corominas 1995, Aguilar-Fernández 2008) – and generated deep conflicts that persist in present times. Therefore, this can be considered as a socioeconomic failure on the part of the constitutional actors and those who might have held vested interests at any level.

In sum, based on what has been exposed in the latter two sections and magnified through the lens of path dependence theory, the transformational process and the *outcome* in Doñana can be assessed as unexpected and, more generally, as contingent, for they defy the universalistic principles of neoclassical economics – particularly in terms of success, efficiency and overall optimality. In other words: the principles of neoclassical economics can account neither for the transformational process nor for the Doñana *outcome*. However, both happened. I now turn to the task of working out the 'why' and 'how' they happened in the context of the broad theoretic-analytical question exposed in the introduction to this Chapter. The more specific questions are: (1) Was the process that led to the Doñana *outcome* triggered by irrational, unexpected or random events and behaviours, or was it unpredictable due to an incomplete analytical framework? In other words, can the Doñana *outcome* be predicted using a more complete framework? More in general, can we modulate contingency? (2) What is the explanatory potential of political-economic interests, discourses and power as factors contributing to shape the Doñana *outcome*?

6.3.2. Refining the historical pattern: Steps towards modulating contingency

As argued above, two sets of mechanisms posed by the *historical pattern* already reduce the degree of unpredictability associated to the Doñana *outcome*. The first one deals with the bottom-up response of the collective-action actors to the increasing returns being produced by the constitutional-level institutional matrix, as well as with the mechanisms underlying the ensuing self-reinforcement dynamic. The second one deals with certain top-down political and power factors at the constitutional level.

In the following sections, based on those two sets of mechanisms, I will build an alternative explanation that refines the *historical pattern*. First, I will clearly specify the set of increasing returns and self-reinforcing mechanisms, in order to show how such specification connects logically with my argument on the need of two additional conditions as necessary mechanisms to account for the Doñana *outcome* (Section 6.3.2.1). Second, I deal with those two conditions: (1) a discursive factor that, guided by the p-IAD, I analysed in its relationship with the second (political and power) set of mechanisms identified by the *historical pattern* (see Section 6.3.2.2); (2) an entrepreneurship component (see Section 6.3.2.3).

6.3.2.1. Increasing returns and self-reinforcing mechanisms

According to the *historical pattern*, from the second half of the 19th century until 1937, the constitutional-level institutional matrix steadily provided massive increasing returns through top-down processes. In particular, it provided the lands surrounding the marshlands with exchange value and potential for diversification, as well as collective-action actors with easy access to – or even direct transference of – property rights, and financial incentives to develop infrastructure. Until the 1980s, such matrix continued to incentivise, at a larger scale, the mobilisation of actors downstream, through the promotion of on-the-ground investments for the full transformation and agricultural exploitation of the marshlands. Self-reinforcing mechanisms such as learning and coordination effects, large setup costs and adaptive expectations operated along the process, as follows[37]. The first two operated along the increasing-returns and self-reinforcement phases; the latter two, solely during the self-reinforcement phase. Large fixed costs started to operate once the first large irrigation infrastructures were in place, at the beginning of the 1950s; adaptive expectations, once the rice sector started its full development and entered the national and global market (1960s-1970s). In sum, increasing returns were signalled from the constitutional-level institutional matrix all

[37] See Section 2.3.3.1. Self-reinforcing mechanisms underlying increasing returns are defined in this thesis as: (1) large setup or fixed costs, which create a high pay-off for further investment in an already established single option; (2) learning effects, if knowledge gained in the recursive operation over the resource system or ecosystem lead actors to be more efficient and get higher returns from continuing use; (3) coordination effects, if the individual benefit increases as others adopt the same option; (4) adaptive expectations, where increased prevalence of selected options enhances beliefs of further prevalence (adapted from Arthur 1988, North 1990a).

along the process, and, after 1937, a clear systemic self-reinforcement pattern started to unfold, pushing the Doñana water socio-ecosystem towards a certain trajectory. It was the realisation of that dynamic which led me to term the 1937-1980s period as 'self-reinforcement phase', differencing it from the previous period, the 'increasing-returns phase'. The latter, although also characterised by the self-reinforcing mechanisms that underlie increasing returns, did not show signs of a systemic self-reinforcement dynamic.

However, this set of mechanisms was as a necessary but not sufficient condition for the emergence of the *outcome*. I agree with the insight that, although increasing returns can result in alternative, far-from-equilibrium paths (if an equilibrium does exist at all), its selection may also result from the occurrence of externalities and other mechanisms decreasing the likelihood of such paths or the attractiveness of other alternatives (Arrow 2000, Kay 2005, Vergne and Durand 2010). I argue that two other conditions were necessary as mechanisms producing the Doñana *outcome*. On the one hand, a hegemonic dominant discourse that acted as a source of streamlined assumptions, ideas and knowledge for mobilising power, top-down from the constitutional level. On the other hand, an entrepreneurial component that acted as a mechanism for action in an environment of extreme uncertainty. I will deal with these two conditions in the following sections.

6.3.2.2. Politics, discourses and power

According to the *historical pattern*, during the self-reinforcement phase, certain political and power factors at the constitutional level played a key role in decreasing the attractiveness of alternative courses of action. These factors include the increasing interventionism and bureaucratisation of the authoritarian and autarchic government, and the action of the powerful technocratic corps of the State (mainly the forest and civil engineer corps). Regarding the latter, the *historical pattern* refers, for example, to: coercive changes in property arrangements; the exclusion of "unproductive" marshland from nature conservation legislation; the promotion of economic maximisation schemes for forestry in the vicinity of the marshlands (e.g., legislation such as the Forest Heritage Acts of 1941 and 1957) and agriculture in their interior (e.g., strategies such as the Guadalquivir-FAO Project, Almonte-Marismas Plan); cooption mechanisms within

the emergent wetland conservation institutional regime; and the replacement of change champions by old-school engineers (e.g., J.A. Valverde). Despite the existence of several 'windows of opportunity' and the occurrence of several water and environmental crises, these constitutional-level mechanisms, operating mainly at the end of the self-reinforcement phase, imposed a command-and-control, 'inherent institutional logic' that curtailed institutional reorganisation and renewal. In other words, they led to institutional reproduction and continuity (i.e. output inertia), and, eventually, to a highly resilient *outcome*.

These top-down (political and power) mechanisms, together with the bottom-up (increasing returns) mechanisms described in the previous section, already reduce the unpredictability associated to the *outcome*. However, the notion of contingency continues to be very powerful, for it still signals a bizarre historical process along both the increasing-returns and the self-reinforcement phases (especially the latter). The arguments that (1) collective-action actors were inefficiently allocating resources in response to speculative expectations on massive increasing returns produced by the institutional framework, and (2) constitutional actors were reproducing command-and-control for the sake of power and economic maximisation logic, are not satisfactory in isolation. It is striking that command-and-control continued to pervade the institutional framework and the large-scale transformational process started and progressed on the ground, in spite of negative feedbacks signalling broad operational inefficiencies. In terms of economic policy, the choices made at the self-reinforcement phase are difficult to justify against other policy and institutional alternatives with significant socioeconomic potential (e.g., the costs and consequences of doing nothing; the preservation and empowerment of traditional economic and ecological knowledge; or the comprehensive protection of all the remnant marshland and wetland ecosystems, thus promoting the extraction of wildlife products, scientific research and nature tourism). After the analysis of the core logic of economic phenomena at the collective-action level, analysis must now turn to the behaviour of the constitutional-level actors, which signals unexpectedness in the recurrent reproduction and continuity of command-and-control schemes. Contingency is thus assessed at a different level of study, the level of politics.

The p-IAD highlights how political interests and discursive factors played a major causal role in the determination of the *outcome*, prompting, in particular, the mentioned command-and-control institutional logic. Looking at the case diachronically, I argue that a discourse conveying the idea of irrigation agriculture and hydraulic infrastructure as a panacea for economic prosperity in Spain played a major role, by providing a powerful justification for the drive to centralise the power of the state, structure the institutional framework and narrow down the available choices for actors at all levels. Based on its origins in the "regenerationism"[38], and intellectual movement that emerged in the 19th-20th change of century, I will refer to it as the 'hydraulic-irrigation regenerationist discourse' (HIR discourse hereafter; see its main features in Table 17). This conception is certainly not new, to the point of being almost a truism. Its novelty rests on the idea of formally integrating this factor in a study of path dependence aimed at illustrating how randomness might be systematically eroded, and contingency modulated. Therefore, I do not focus on a detailed descriptive account of the discourse, for which numerous scholars have provided more detailed and nuanced analyses than the one I aimed for here (e.g., Orti 1984, Gómez-Mendoza 1992, Sánchez 1997, Swyngedouw 1999, Fernández 2000), thus avoiding a revisionist account of this issues. My aim is strictly focused on a confrontation of empirical data and secondary interpretations, with theoretical content, with the purpose of tackling the theoretic-analytical question exposed in the introduction to this chapter. With a focus on the 20th century, the following account provides proof of how the HIR discourse: (1) endured in spite of political gridlock and deficient implementations at the beginning of such century; (2) persisted and progressively constituted as the dominant source of streamlined assumptions, ideas and knowledge for mobilising power top-down from the constitutional level in posterior periods; (3) causally contributed to the Doñana's rigid *outcome*.

Along the Restoration period, the HIR discourse was absorbed at a political level, owing to decisive actions taken by Rafael Gasset. Several times Ministry of Public Works, he assumed the main arguments of Joaquín Costa, the key ideologist of the hydraulic-irrigation paradigm (Orti 1984, Gómez-Mendoza 1992, Mateu 2002).

[38] From the Spanish "regeneracionismo", an intellectual movement that sought to objectively explain the decline of Spain as a global economic and political power.

Table 17. Main attributes of the hydraulic-irrigation regenerationist discourse

Attribute	Description
Roots	Enlightened reformism and liberalism of the previous two centuries. Examples: program for agrarian development proposed by J. Costa to the High Chamber of the Upper Aragón (1892-1893); Enlightened Plan of Promotion of the Province of Sanlúcar de Barrameda (Cádiz, 1805)
Political-economic context	Fin-de-siècle Agrarian Crisis: readjustment of global agricultural trade, loss of overseas colonies triggering increases in tariff barriers for traditional unirrigated crops (cereals, vineyards and olive groves)
	Disenchantment with the poor results obtained by past liberalist, laissez-faire hydraulic policies using various incentives (subsidies, economic aids and fiscal exemptions) to foster the private sector as the main driver in the building of primary hydraulic infrastructure
	Huge public drive towards infrastructure development (roads, railways and hydraulic infrastructure) through new types of subsidies, economic aids and fiscal exemptions, aimed at incentivising the co-participation of the private sector, for example, in the irrigation business – i.e. towards the "material reconstruction" of the country
	Chronic budgetary crisis and contemporary deficit of government finances following the Cuban War
Main expressive means	Media (newspapers, e.g., "El Imparcial"), official documents (planning documents, e.g., National Plans of Hydraulic Works; legislation, e.g., Gasset Act, Cambó Act); institutional (speeches, e.g., before the Parliament, in agricultural organisations)
Features	Irrigation agriculture (intensive and industrial) as a privileged means for economic modernisation throughout the country, focusing on modernisation and increased production, thus avoiding the alternative option of land reform and redistribution to reduce the rampant inequality between labourers and land owners
	Ideas about the need to maximise water use efficiency, inherited by the anterior period of Liberal Reform and forwarded as the key for the consolidation of the liberal state
	Hydraulic policy as a reconstructive economic policy. North-south hydrological differences conceived as a geographical imbalance (topographic and climatic), whose resolution would, in turn, resolve the ancient Spanish agrarian problem and the "ills afflicting the fatherland" (from the Spanish "los males de la patria")
	The need for the State to build and exploit primary hydraulic infrastructure was "common sense doctrine", based on the argument that costly public investments constituted reproductive spending
	Representative characters: Rafael Torres Campos, Ricardo Macías Picavea, Fermín Caballero, Lucas Mallada, Andrés Llauradó, Horacio Bentabol, Pedro M. González Quijano, Celedonio Rodrigañez, Joaquín Costa, Rafael Gasset, Lorenzo Pardo
Illustrative discursive fragments	"It is urgent to rebuild the geography of the country, in order to resolve the political and social matters" (Costa 1911)
	"Current social and agricultural progress in Spain depends on rainwater, and water springs and reservoirs. Such water must be the task of the nation, and the agricultural Congress must address both the Parliament and the Government for their urgent claim, as the supreme desideratum of Spanish agriculture" (Costa 1911)
	"...the day that all the water of the Pyrenees remains in the plain, our province alone will produce as much as ten provinces together, and there will be for all, income and luxury for the rich, independence and well-provided table for the poor, high and uninterrupted wages for workers, substantial alms to the destitute, large payments to the treasury, rest and comfort for all..." (Costa 1911)
	"Canals and reservoirs must be built by the State; if built by the private sector, the remedy would be worse than the disease" (Costa 1911)
	"…government must be willing to take charge, as a function of the State, the building of canals and reservoirs, for which it will present, within a year, a bill for a general Plan aiming at such purpose" (Gasset 1899, cited in Sánchez 1997:324).

Table 17 (cont'd). Main attributes of the hydraulic-irrigation regenerationist discourse

Attribute	Description
Key conceptions and dichotomies	Water of rivers is lost to the sea, hydrological differences constitute a geographical imbalance (topographic and climatic), existence of "two Spains" (wet North and dry South), two types of basins (ones negatively balanced and others positively balanced), need for hydro-solidarity among regions

Sources: own elaboration based on the primary and secondary sources used in this section, the latter being also used for increasing objectivity. Main secondary sources include e.g., Orti (1984), Moral-Ituarte (1991), Gómez-Mendoza (1992), Sánchez (1997), Fernández 2000)

Gasset, together with other liberals and the Civil Engineering Corps, promoted the discourse in both the media and the Parliament, which was formed by a system of two main parties, the conservative and the liberal, under a constitutional monarchy (Díaz-Marta 1989, Sánchez 1997). The promotion of this discourse resulted in major institutional and organisational changes during the Restoration period (Table 16), reflected in a progressive shift of the role of the State: from a mere subsidiary of hydraulic infrastructure, to the active promotion and implementation of such type of infrastructure. This shift formed part of a more general, long-term plan that consisted of three broad political-economic stages: (1) a period of "material reconstruction" of the country (see Table 17) through the construction of primary infrastructure (e.g., roads, railways, hydraulic infrastructure) led by the state and financed through the emission of public-debt instruments; (2) a period of settlement of the debt that was being generated by the emission of such instruments; (3) progressive inhibition of the state from economic life (Sánchez 1997). For the construction of secondary hydraulic infrastructure, the state largely relied on co-participation instruments (e.g., partnerships with local irrigation unions and private landowners) and fiscal ones of 'georgist' inspiration (e.g., taxation of land value) (Sánchez 1997, p. 343,349).

However, I argue that during the Restoration period, the HIR discourse played mainly a rhetorical role and utopian unifying symbol based on powerful logics (logos) and capacity to appeal to emotion (pathos) (Table 17). By 1933, after the dictatorship of Primo de Rivera, a very limited fraction (about 12%) of the primary infrastructure and irrigated land surface projected by the regenerationist General Plan of Irrigation Canals and Reservoirs of 1902 and its subsequent revisions (see Table 16) had been carried out. The poor level of implementation was blamed on the technical deficiencies of the plan and the lack of a concurrent state policy securing the needed financial resources (Pardo

1933, p. 17-42). However, the most probable causes behind the implementation failure along the Restoration were factors of political, power and administrative nature acting as cogwheels of political gridlock and irregular financial resources, such as: (1) general lack of political will to implement a large-scale strategy requiring a huge increase of public spending, via the difficult reform of a fiscal system based on indirect taxes, i.e. a reform that would have been detrimental for the wealthy classes; (2) persistent *fear to budgetary deficits*[39] of the conservatives stemming, mainly, from the government's low capacity for tax collection and an inherited deficit of the government finances following the Cuban War, and resulting, in practice, in the withdrawal of public funding for hydraulic infrastructure; (3) a non-democratic Parliamentary system dominated by oligarchic groups defending their private interests, contrary to the fiscal reforms needed to increase the state's tax revenues, hence its capacity to fund the "material reconstruction" of Spain; (4) strong opposition by local overlords in Parliament to changes in long-standing administrative procedures warranting them preference order in government concessions, to a system based on technical criteria, i.e. reversion of norms perpetuating their powerful influence which, in some cases, was a direct expression of their despotism (summarised from Moral-Ituarte 1991, Sánchez 1997, Fernández 2000, Mateu 2002).

In sum, during the Restoration period the overtly liberal HIR discourse continued to configure as the political, progressive solution to the so-called Spanish agrarian problem in successive plans, until the National Plan of Hydraulic Works of 1933 (see Table 16). This discourse also constituted an alternative to the protectionist reactionary option of increases to tariff barriers for traditional unirrigated crops (cereals, vines and olive trees) (Sánchez 1997, Fernández 2000). Based on it, some results on the ground were achieved along the 1920s, funded through the emission of public debt instruments justified over the general argument that the related expenditures constituted investments with long-term returns due to the future generation of taxable income – rhetorically termed as "reproductive spending" (see Sánchez 1997). However, a privileged conservationist political elite had at their avail powerful institutional mechanisms for producing political gridlock and maintaining a status quo and power positions that protected their short-term interests, hence hindering reforms that were supposed to bring

[39] From the Spanish *"santo temor al déficit"*, a term coined by literature Nobel-prize winner and Minister of Finance José de Echegaray.

long-term economic prosperity through irrigation agriculture supported by hydraulic infrastructure.

The dictatorship of Primo de Rivera (1923-1931) was largely continuist of the previous period and also poor in terms of implementations. However, despite its poor application on the ground, the HIR discourse persisted throughout the ensuing periods. During Franco's dictatorship (1939-1975), the more comprehensive and technical National Plan of Hydraulic Works of 1933 of the II Republic was fully implemented through the almost identical Plan of 1940 (Table 16). Both plans were, in turn, amply based on the rethoric of both the Water Act of 1879 (repealed more than one century afterwards, in 1985) and the Restoration's 1902 plan – and its subsequent revisions –, thus inheriting a clear hydraulic character and regenerationist mark (Ortega 1984, Moral-Ituarte 1991, Gil 2001). Franco's government largely abandoned the reformist aspects of the 1933 plan and undertook, through fundamentally technical interventions, the major hydraulic transformations of the 20th century. At this point, the hydraulic-irrigationist idea, a socioeconomic panacea largely originating in the regenerationist movement, but tracing back to the liberalism and enlightened reformism of the previous two centuries, was being successfully institutionalised and implemented at large scale for the first time.

Three radical institutional changes took place at this point in time. First, at the constitutional, strategic level: the comprehensiveness and interventionist character of the National Plan of Hydraulic Works of 1933, inherited by that of 1940. The plan of 1933 constituted the instrument of the Irrigation Act of 1932, through which the state financially assumed, in full, the construction of both primary and secondary irrigation hydraulic infrastructure, and took a main role in the colonisation-and-development strategies[40] (Sánchez 1997, p. 359, Gil 2001, p. 12, Moral-Ituarte 1991, p. 498, Barciela and López 2003). Second, at the collective-choice, organisational level: the creation of the Water Union Confederations[41], semi-autonomous organisations financially-guaranteed by the Ministry of Public Works (Table 16), in 1926. They were entrusted with the management and maximisation of the agricultural, forestry and hydropower

[40] The National Plan of Hydraulic Works of 1933 (Pardo 1933) was carried out by the Centre for Hydrographic Studies, created by Decree and directed by Manuel Lorenzo Pardo, president of the recently created Ebro Water Authority.
[41] From the Spanish "Confederaciones Sindicales Hidrográficas", the precursor of the modern Water Authorities ("Confederaciones Hidrográficas").

yield of water resources at the basin level, bringing together the widest range of regional stakeholders, but promoting the national interest to the detriment of local ones (Sánchez 1997, p. 358, Gil 2001, p. 11). This role soon diffused from the Ebro Confederation, the first to be created, throughout the rest of Confederations subsequently created (Segura, Duero, Guadalquivir and Eastern Pyrenees; Díaz-Marta 1989, p. 21). Third, at the ideological level: an emphasis on the need to establish a hydrological balance between the Atlantic and the Mediterranean basins, based on the argument of the higher agricultural productivity and economic potential of the former, and the lack of planned works implemented in the latter (Ortega 1984, Gil 2001).

The right and left banks of the Guadalquivir Estuary were both affected by the same institutional and discursive factors described above, with a key difference with the rest of the country: the available financial resources for the regenerationist "'material reconstruction" were not diverted to hydraulic infrastructure, but to the enhancement of river navigability and the Seville's port infrastructure, until the early 1930s (Moral-Ituarte 1991, p. 454). With respect to the HIR discourse[42], my subject of interest, it can be argued to having started to exert an effect in the 1920s, providing impetus to the first private companies for transforming the Guadalquivir marshes into a "new Nile delta" (Sabuco 1997, p. 56, Table 16). The public and private transformational attempts that took place during that decade occurred under the protection of legislative (e.g., Cambó Act) and incentivising (e.g., financial and tax-reduction instruments, direct transfer of property rights, no need to justify investments) instruments charged with regenerationist ideas (Table 16). In particular, they promoted the transformation of an extensive typology of lands traditionally considered as "unhealthy and unproductive", such as lagoons, marshlands and wetlands. However, the largest regional transformations started during the 1940s, and reached their maximum splendour during the 1960s and the 1970s, under the protection of a battery of regulations deeply rooted in history (Table 16). During these two decades, a number of primary hydraulic infrastructures started or planned in previous periods by the State, private companies or the Guadalquivir River Authority, were completed (Table 16). The action of the latter, created in 1927 as a Water Union Confederation, was crucial in two main senses. Ideologically, due to the inheritance of the responsibilities for the maximisation of resource yield (Moral-Ituarte

[42] See also Zouwen 2006 for an analysis of discourses produced on the ground.

1991, p. 492); and, operationally, due to its role in regulating and streamlining irrigation activities all over the basin, through reservoir control (Moral-Ituarte 1991, pp. 499,510) – which has been fundamental in the development of technically efficient rice agriculture in Doñana. All these changes were protected legislatively (e.g., Colonisation of Large Areas Act of 1939) and rooted in the acknowledgement, by the National Plan of Hydraulic Works of 1933. That regulation was key for the irrigation in the marshlands already transformed for "sanitation and colonisation" purposes (Pardo 1933, p. 209).

At this point of the analysis, however, these two broad bottom-up (increasing-returns) and top-down (politics, power and HIR discourse) mechanisms appeared as still insufficient to provide a satisfactory explanation about the Doñana *outcome*. The IAD served this time as a device highlighting what was lacking in the analysis. The IAD and, by extension, the p-IAD, implicitly consider the idea of actors as fallible and adaptive learners. As described in Chapter 2, Section 2.3.1, they are depicted as able to operate under uncertainty, and holding both cognitive and information-processing capability (bounded rationality[43]), but also able of learning from error (adaptive learning), i.e. as fallible learners (McGinnis 2011). However, the IAD device lacks a component allowing the analysis of how adaptive learning is operationalised in a real-world situation characterised by high uncertainty on the effect of management action. In this case, huge uncertainties were posed by the water and salinity problems. Therefore, the following questions arise: How and why actors proceed to action in spite of high uncertainty on the benefits of action? In this case, how and why collective-action actors proceeded to transformation in Doñana in spite on the huge uncertainty on the benefits to be obtained from rice agriculture? I argue that the entrepreneurship component analysed in the following section must be added up as a necessary condition to provide a satisfactory explanation of the Doñana *outcome*. Recent theoretical insight argue that (whether as champions, facilitators, visionary leaders or knowledgeable individuals) entrepreneurs show a great competency to work in and transform complex social-ecological systems by, for example: (1) changing "beliefs, in particular, by convening all stakeholders around a common vision"; (2) changing "the flow of political authority and resources, in particular, by playing key roles in networks and mobilising social

[43] It is worth noting again that this view of the actor, in particular, bounded rationality (Simon 1955), is reactive to the view of rationality as optimisation of neoclassical economics.

capital"; and (3) challenging "technical and legal frameworks, in particular, by encouraging integration of local knowledge, experimentation, and new scientific frameworks" (Westley et al. 2013). In next section, I show how this might be applied to the Doñana case, i.e. how the entrepreneurship component must be added up as a necessary endogenous condition for a satisfactory causal explanation of the Doñana's transformational process that led to the rigid *outcome* at a systemic level.

6.3.2.3. Entrepreneurship component

The entrepreneurship component consisted of two main endogenous factors: (1) the action of Rafael Beca, an experienced entrepreneur that managed to initiate the full development of the rice sector, which would eventually end in a market-based economy; (2) the action of Valencian rice growers, a pioneering workforce attracted by Beca that introduced crucial innovations and productive factors. Uninterrupted rice cultivation in the Guadalquivir marshlands started in the midst of the Spanish Civil War. In 1937, Rafael Beca was entrusted with the development of rice agriculture in Isla Mayor by the Francoist faction, in order to ensure rice supplies – since the main rice production centres were in hands of the Republican faction (Sabuco 1997, González-Arteaga 2005, p. 121). Beca received political, financial and technical support and carte blanche from the recently established dictatorial regime, through the Guadalquivir River Authority, and the National Institutes of Colonisation and Housing. From 1939 onwards, three periods ensued, characterised by the State traditional interventionist colonisation-and-development strategy, and marking a transition from traditional to mechanised farming (for a more detailed description see Sumpsi 1980, Moral-Ituarte 1993, González-Arteaga 1993, González-Arteaga 2005):

1. Take-off (1940s-1950s). This period was characterised by a constant increase in both the number of rice growers and cultivated surface, and by relatively large farming plots that were increasingly acquired by the farmers. The 1940s were an experimental period, along which technology use was minimal and most tasks performed by hand. In the 1950s, there was a large-scale process of increasing modernisation of agricultural practices (mechanisation, fertilisation, improvement of crop varieties) facilitated by a partial liberalisation of the agricultural sector, and by an increase in farming incomes and the wages of rice growers, due to the combined

occurrence of emigration phenomena and the continuation of practises that diminished labour costs (e.g., direct sowing).

2. Acceleration (1960s-1970s). This period was characterised by a curb in both rice growers and cultivated surface, by the concentration of land ownership, and by huge advances in modernisation, coinciding with a progressive liberalisation of the sector. During the 1970s mechanisation outcompeted labour, due to an increase in labour's costs, combined with the full mechanisation of direct sowing with tractors and light aircrafts, and other improvements such as the use of enhanced seed varieties, herbicides, combine harvesters and rice drying techniques.
3. Sustained growth (1980s-1990s).

First Valencian rice growers arrived in the 1940s. They doubled their numbers by the mid-1970s with the "boom" of rice agriculture, representing 6.7% of the total population of the marshlands by 1981 (González-Arteaga 1993). They are regarded not only as the quantitative, but also the qualitative human component driving the take-off of rice agriculture, introducing innovative productive factors that were diffused among the already established, mostly Andalusian, workforce (González-Arteaga 1993, Sabuco 1997, Muñoz 2007). They were first attracted by an advantageous tenancy regime and the promise of future ownership offered by Beca, who also steadily favoured their arrival during the 1940s, as he was aware of the novel productive factors that they brought along with them (González-Arteaga 1993, p. 79, Corominas 1995, p. 67, Sabuco 1997, p. 60, González-Arteaga 2005, pp. 125,197,202). Amongst the most important were, for example: (1) a differential, intrinsic belief in the feasibility and economic profitability of rice agriculture in the marshlands based in previous experiences, which contrasted with the local history of extractive, subsistence economy, and the associated scepticism towards any transformational attempt; (2) the importation of innovations and know-how from their homeland (e.g., Albufera of Valencia) that outcompeted other techniques imported in the past from the Nile or the Ebro deltas; (3) a rather novel, family-based work culture oriented around rice growing, in which women played a major role reconciling housework and farming tasks (Sabuco 1997, González-Arteaga 2005). It is also worth noting that the capital generated by rice agriculture in the Guadalquivir sector has not been traditionally invested in industrial development, but re-invested in further modernisation and mechanisation of rice

growing techniques, and research and development associated to them (González-Arteaga 2005, p. 173).

6.4. Concluding remarks

This chapter, through explanation building and a second theoretical iteration, has offered an alternative explanatory pattern refining the *historical pattern* of Chapter 5 about the current rigid configuration of the Doñana's regime for water resources management and wetland conservation. The findings reported above justify the following concluding remarks:

- The second theoretical iteration, through which I re-examined the *historical pattern* and the causal, path-dependent mechanism posited by hypothesis h_1 of the thesis, has shown how the Doñana's rigid *outcome* is more expected to occur if a more comprehensive analytical framework is used, in this case, the p-IAD.
- In the Doñana water socio-ecosystem, I argue that three mechanisms were necessary and sufficient conditions for the transformational process that led to the Doñana's rigid outcome: (1) a contextual political-discursive mechanism that mobilised power top-down and signalled increasing returns to actors downstream of the institutional regime; (2) the operation of increasing returns and self-reinforcing mechanisms bottom-up; (3) an endogenous entrepreneurial component that acted as a mechanism for action in an environment of extreme uncertainty.
- The investigation of political, discursive and power contextual factors, guided by the p-IAD, proved instrumental to unveil these mechanisms, shedding light over the components determining the Doñana *outcome*.
- This type of investigations may help in avoiding premature assessments of local randomness and, through the use of enhanced epistemological devices, it might shed light on upper, structural factors that constrain decision and action downstream.

Next chapter (Chapter 7) turns to a general discussion of the results of the thesis, including a re-evaluation of hypothesis h_1 and the paradox of contingency taking into account the findings of the second theoretical iteration of the institutional analysis presented in Chapter 6.

Chapter 7. General discussion

As outlined in the introduction, the scope of this thesis is the investigation of the institutional conditions for a change towards the sustainable use of natural resources and ecosystems in coupled social-ecological systems, which was approached through an in-depth single-case study: the Doñana region. Within that scope, I focused on the institutional conditions required for transitions from command-and-control schemes towards more flexible and adaptive approaches for policy and decision making at the governance and management levels, i.e. adaptive governance and adaptive management. This focus relied on the assumption that an enhanced understanding of the current policy and institutional architecture in social-ecological systems would facilitate, in turn, an enhanced understanding of the effect of such architecture on the target design needed for adaptive governance and management. Through my case study and a qualitative research design, I addressed three interrelated, general questions of research interest. The first one has implications for the issue of public participation in the process of transitional design, while the other two have implications at a theoretic-analytical level. They were established as follows:

1. Evaluating the usefulness of action and participatory research for the implementation of broad-scale, multi-level participatory processes for water resources management and wetland conservation.
2. Identifying the roots of the institutional rigidity that characterises certain maladaptive social-ecological systems.
3. Exploring the explanatory potential of political-economic interests, prevailing discourses and power as factors contributing to shape local social-ecological systems outcomes, especially when the core logic of path dependence, composed by the mainstream principles of neoclassical economics, fail to predict observed outcomes in historical, evolutionary perspective.

These research questions were addressed in four consecutive research stages guided by a *grand tour* question, a main research aim and four corresponding specific objectives.

A fifth objective was to develop policy guidance and recommendations for future implementations of more flexible, participatory and adaptive approaches in the Doñana region, based on the results of the research (for an overview of the major findings of the thesis by specific objective see Chapter 8). The order of exposition of the research stages broadly reflects the actual process of investigation. It also reflects how the need to investigate the last two questions exposed above was progressively informed by the research carried out in the initial phases of the thesis, which focused on the first. In the next sections, however, I will discuss my research questions and results in a different order, by way of continuation of and to facilitate the reading of the line of reasoning underlying the evaluation of the core process of theorising, hypothesis h_1 and the paradox of contingency.

Therefore, I first discuss the findings of the institutional analysis carried out in Chapters 5 and 6. This discussion includes: (1) a thorough re-evaluation of hypothesis h_1 and the paradox of contingency by discussing, in a more integrated way, the concrete mechanisms underlying the Doñana's rigid outcome (Section 7.1); (2) a speculation on the possibilities for escaping the rigidity trap in Doñana (Section 7.2). Second, I discuss the action-research program in the context of the institutional analysis, including: (1) an evaluation of the insights from the action-research program (Section 7.3); (2) the implications of the research within a European institutional context (Section 7.4). Finally, I offer an evaluation of the main methodological limitations of the research (Section 7.5), and an outline of the main lessons learnt and directions of further research that can usefully build on this thesis (Section 7.6).

7.1. Modulating contingency: Historical mechanisms underlying the Doñana's rigid outcome

In this section, I re-evaluate both hypothesis h_1 and the paradox of contingency. As in Chapter 5, Section 5.5, my evaluation is rather abstract and parsimonious. Here, I make the case for systematising the role of discourses and entrepreneurship factors in their relationship with political-economic and power into the analysis, for diminishing the degree of contingency associated to the Doñana's rigid outcome. Complemented by Section 7.6 on lessons learnt and directions of further research, my discussion here deals, in general, with contingency as a property of the concept of path dependence that

can be modulated in explanations of institutional dynamics in social-ecological systems. This type of advancements would contribute to increase our capacity to predict the likelihood of certain types of outcomes. In turn, this would help in better informing future policy and institutional designs for successful transitions towards adaptive governance and management in social-ecological systems, hence improving the prospects for the more sustainable use of natural resources and ecosystems.

Hypothesis h_1 was established as follows:

h_1: *The historical recurrence of 'command-and-control schemes' is a 'path-dependent process' that has led to the emergence of a 'rigid institutional regime' for water resources management and wetland conservation in the 'Doñana water socio-ecosystem', and caused it to enter and get trapped in a 'maladaptive stable state'.*

As argued in Chapter 5, Section 5.5, based on path dependence theory and its logical core from neoclassical economics, this overall rigid outcome (rigid institutional regime and rigidity trap) was not a necessary or expected outcome of the preceding events or behaviours that occurred during the first critical juncture (CJ1; Fig. 16, Table 15). Those events and behaviours sought economic efficiency and productivity through the implementation of command-and-control schemes for water resources management (and, more recently in history, for wetland conservation). It can then be postulated that the institutional regime for water resources management was, at a certain point in history, subjected to purportedly random events or behaviours, or more generally, subjected to contingency. These events or behaviours, in turn, can be postulated as having launched the regime through an unpredictable path that diverged from a more expected path of optimal performance. In other words, negative feedback mechanisms steering the regime and actors towards a path-independent, optimal equilibrium, did not seem to operate in Doñana. In sum, the Doñana's rigid outcome represents a path-dependent, inefficient and sub-optimal one that can be qualified as contingent.

But, is this outcome totally unpredictable? I argue that it is not, based on the line of reasoning exposed below, which shift to a more concrete discussion of the facts underlying the abstract phenomenon exposed in the previous paragraph. The more specific questions are: (1) was the process that led to the Doñana outcome triggered by

irrational, unexpected or random events and behaviours, or was it unpredictable due to an incomplete analytical framework? In other words, is the Doñana outcome indeed a contingent phenomenon, or can it be predicted using a more complete framework? More in general, can we diminish the perceived degree of contingency by further enriching the theoretical framework of the investigation, i.e. can we modulate contingency? (2) What is the explanatory potential of discourses and entrepreneurships in their relation with political-economic interests and power, as factors contributing to shape the Doñana outcome? In general, what is the role of these factors in modulating contingency? (3) Can we increase our capacity to predict the likelihood of certain types of outcomes, hence better informing future policy and institutional designs for successful transitions towards adaptive governance and management in social-ecological systems? I will provide an answer to these questions parsimoniously, in order to include the insight gained in the institutional analysis with care. Regarding the evaluation and discussion of hypothesis h_1 and the paradox of contingency, given that the necessary mechanisms have occurred, the challenge is to explain such mechanisms and the outcome in context, as opposed to assuming that they were just a product of local random chance, deep in history.

According to the historical pattern presented in Chapter 5, after CJ1 the "winning" institutional configuration was one imbued with institutional arrangements based upon command-and-control schemes for water resources management at the estuary level. These arrangements, which were focused on economic/organisational efficiency and the maximisation of productivity, appeared to have competitive advantages over alternative approaches (e.g., self-sufficient economies based on traditional ecological knowledge). They capitalised on their advantages during the early periods of the juncture and became locked in within the institutional regime for water resources management in posterior periods.

In my view, the lock-in of command-and-control at the operational levels was facilitated by increasing returns and self-reinforcing mechanisms and favoured by past structural flaws (e.g., inter-scale institutional void before CJ1). These mechanisms operated before and during the 1920s, until 1937 (last part of the increasing-returns phase), despite the verified inefficiency of the approach (i.e. despite Ω'-type crises). The clearest example involves the collective-action actors' expectations about the returns on investments in

innovative technologies, agricultural development, and engineering works supported by public funding. Incremental investments in public and private infrastructure led to large set-up costs that created, in turn, increasing payoffs for further investments in infrastructure and transformative technologies. As they gained experience and knowledge from the recursive operation over the hydro-ecological system, actors were affected by learning and coordination effects, and benefited increasingly from the extension of command-and-control schemes to water resource management and marshland/wetland transformation (i.e. actors were r-strategists).

Can this behaviour be qualified as irrational or random? I argue no; collective-action actors were behaving neither randomly nor illogically, but responded instead through positive feedback to the constitutional institutional matrix, a higher structural entity. Borrowing from David (2001, p. 30), it is misleading to pose economic irrationality or implementation errors in Doñana, since collective-action actors were subjected to positive network externalities (e.g., coordination effects). They were, if something, picking "the right horse", based on their expectations and projections on how the future was to unfold, hence adapting their actions "in ways that help make those expectations come true" – in summary, having and following adaptive expectations (Arthur 1994, p. 112). They were responding to the driving force of incentives, which, in words of North (1990, p. 112), constitutes one of "the most constructive building blocks of neoclassical theory". Of course, especially when facing the knowledge generated by the infrastructural and agricultural failures that took place during the increasing-returns phase (Table 16), the set of mechanisms that operated along the increasing-returns phase was largely steered by speculative presuppositions that, upon examination, proved to be overly unwarranted.

Moreover, it is probable that my research findings are not just hindsight. It is my contention that the environmental and socioeconomic factors that made the transformational process a counterintuitive endeavour, against the core logic of neoclassical economics (see Chapter 6, Sections 6.3.1.1 and 6.3.1.2), were largely known to most actors along the last century; explicitly, through well-crafted studies, or intuitively, through experience, at least, so as to allow for making informed decisions towards the protection of their self-individual interest (e.g., calculation of the costs and consequences of doing nothing, different investments). An illustrative example was the

explicit need to reconsider the original transformational goals of the Almonte-Marismas plan aimed at developing irrigation agriculture, evidenced even before the operations started (see Corominas 1970, p. 70, Castells et al. 1992, p. 16).

In this way, after 1937 (beginning of self-reinforcement phase), the institutional regime for water resources management entered a developmental path characterised by the top-down reproduction of institutions aimed at reinforcing the array of command-and-control schemes developed at the operational level. Such institutions sought to recoup costs and incentivise the streamlined operation of the existing structures. In fact, they reinforced the on-the-ground investments for the transformation of Doñana's hydro-ecological systems into productive lands and waters, as well as their intensive exploitation.

The persistence of such institutional configuration during all subsequent periods, despite the existence of several windows of opportunity for the promotion of new ones (e.g., Ω-α' group action, Doñana Act of 1978) and more Ω'-type crises, was rooted in its strong inertia and the power of technocratic elites (i.e. K-strategists). Such elites legitimated and supported, from the constitutional level and through institutional reproduction mechanisms, an inherent institutional logic that curtailed reorganisation and renewal. This was done, for example, by changing the property system, increasing interventionism and bureaucratisation at all levels, or replacing local change champions who would have fostered innovation and change. In other words, the institutional events that took place prior (Autarchic period) and during the second critical juncture (CJ2; see Fig. 16 in Chapter 5) reinforced the regime's path dependence. In that way, and the trajectory of the Doñana's water socio-ecosystem entered a maladaptive rigidity trap characterised by high potential for change, high connectedness, and high resilience, and by a rigid institutional regime for water resources management and wetland conservation at its core i.e. the rigid outcome initially qualified as contingent by the historical pattern.

However, according to the results of the alternative pattern built in Chapter 6, the predictability of the Doñana's rigid outcome can be enhanced if discourses and entrepreneurship factors in their relationship with political-economic interests and power are taken into account through more comprehensive frameworks (e.g., the p-

IAD). More generally, the case can be made that, through the systematisation of those factors in analysis, contingency can be modulated away from randomness or unexpectedness, and towards predictability in explanations of institutional dynamics in social-ecological systems. In the Doñana case, my main arguments for the inclusion of those factors were three: (1) although increasing returns can result in alternative, far-from-equilibrium paths (if an equilibrium does exist at all), its selection may also result from the occurrence of externalities and other mechanisms decreasing the likelihood of such paths or the attractiveness of other alternatives; (2) it is striking that command-and-control continued to pervade the institutional framework and the large-scale transformational process started and progressed on the ground, in spite of negative feedbacks signalling broad operational inefficiencies; (3) based on (2), in terms of economic policy, the choices made at the self-reinforcement phase are difficult to justify against other policy and institutional alternatives with significant socioeconomic potential (e.g., the costs and consequences of doing nothing; the preservation and empowerment of traditional economic and ecological knowledge; or the comprehensive protection of all the remnant marshland and wetland ecosystems, thus promoting the extraction of wildlife products, scientific research and nature tourism). Therefore, after the analysis of the core logic of economic phenomena at the collective-action level, I shifted analysis to the behaviour of the constitutional-level actors untangled by the historical pattern. That behaviour signalled unexpectedness in the recurrent reproduction and continuity of command-and-control schemes. Thus, I turned to the assessment of the level of politics and discourses, discovered along the way the entrepreneurship component and took the first steps towards the modulation of contingency.

Based on the results of Chapter 6, I argued that three mechanisms were necessary and sufficient conditions for the transformational process that led to the Doñana's rigid outcome: (1) a contextual political-discursive mechanism that mobilised power top-down and signalled increasing returns to actors downstream of the institutional regime; (2) the operation of increasing returns and self-reinforcing mechanisms bottom-up; (3) an endogenous entrepreneurial component that acted as a mechanism for action in an environment of extreme uncertainty. At a more abstract level, I conceive the hydraulic-irrigation regenerationist (HIR) discourse as having created a broad, sophisticated meso-level mechanism, whereby the top-down and bottom-up pulls exerted by constitutional actors and collective-action actors, respectively, favoured the unfolding of the

entrepreneurship component (see Fig. 21). In particular, this allowed the innovative action of Beca and the Valencian rice growers to take place[44].

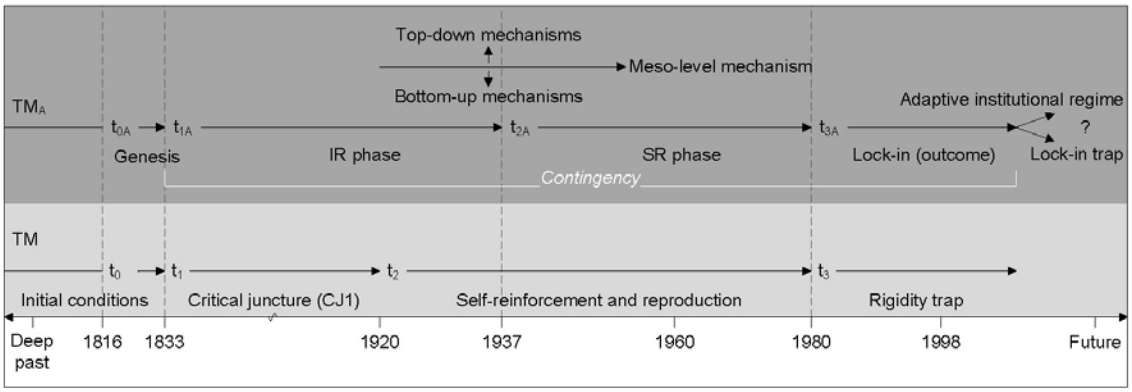

Figure 21. Illustration of the meso-level mechanism that facilitated the unfolding of the entrepreneurship component

IR = increasing-returns; SR = self-reinforcement

Given my arguments, can randomness be exhausted and the contingency signal be abated in Doñana? Do my results therefore invalidate the path dependence hypothesis? I argue not, for two main reasons. On the one hand, within an socio-ecological system, socioeconomic processes lead to deep biophysical and ecological transformations that are largely irreversible, giving rise to early lock-in situations that are very persistent due to the high sunk costs generated, thus eliminating feasible alternative paths at their roots – not to mention the high transaction costs involved in a potential process of institutional change. On the other hand, there is the unpredictability associated with human agency, personified by illustrative actors such as Rafael Beca, the Valencians and J.A. Valverde, whose presence and action in Doñana is subject to a certain degree of randomness. Moreover, Valverde was successful in championing a potent nature conservation counter-discourse, locally reactive to the agricultural transformations, whose expression on the ground eventually led to: (1) a protection-for-conservation race for the salvation of the remnant marshland and wetland ecosystems in the 1950s-60s;

[44] Different questions are the legitimacy of the origins of the power of both constitutional and collective-action actors, and the power differentials created with other actors. While any dictatorship is unambiguously regrettable, it is more productive to distance explanation from pure ideological considerations and focus it on actual mechanisms from which to draw both positive and negative lessons to inform the present and the future.

(2) the purchase, by the newly-created WWF, of crucial marshland areas, which entrenched the "battle" against agriculture along the 1960s; (3) the creation of the Doñana National Park (currently embedded in the wider Doñana Nature Reserve) in 1969 (Valverde 2004). I argue that the timing and sequence of both the appearance of Valverde and this chain of events, overlapping with the process of agricultural transformation described above, led to the actual systemic rigidity trap, instead of a much more difficult-to-escape lock-in trap characterised by a deep erosion of environmental and ecological values (Allison and Hobbs 2004). In other words, it led to a clash of discourses and developments on the ground (worth analysing in the future) that was arguably the result of random chance[45].

Although I have not examined it in-depth, I speculate that the action of Valverde and the Ω-α group during the 1950s-60s was also favoured by the meso-level mechanism mentioned above. But, although Valverde's action constituted a largely horizontal and participatory international process, the creation of the Park marked the return to a top-down process of decision making and its management during the 1970s, was entrusted to old-school engineers through the National Institute for Nature Conservation (Valverde 2004). Moreover, the new counter-discourse clashed with the highly inertial command-and-control paradigm that dominated the existing forestry and water management institutions and organisations, which were, in turn, imbued in the broader national institutions, actors and hydraulic-irrigation regenerationist (HIR) discourse. The incipient marshland/wetland conservation institutions and actors were thus soon absorbed into the mainstream paradigm and became part, as a result, of the rigid institutional regime.

A difficult question arises at this point: Did the polity of the époque, a dictatorial autarchic regime, constitute a necessary condition to trigger a titanic and bizarre transformation in Doñana? This question cannot be definitely answered out of a comparative multiple-case study. It is true that major changes on the ground, at the national level, occurred under the auspices of a polity that propelled transformational processes through authoritarian impositions, capitalising on the HIR discourse. This clearly materialised in the conferred to the elitist Civil and Forestry Engineering Corps

[45] See the recent views exposed in Herrera (2014) characterisng the creation of the Doñana Biological Station as a "black swan".

and similar organisations (e.g., Water Authorities, Directorate General of Public Works), which were organised around tight hierarchical structures and technocratic and bureaucratic approaches to governance and management, under the "command and control" of the central government (e.g., River Basin Authorities; López-Gunn 2009, p. 375). However, several arguments challenge the dependence of the transformational process on the power of the dictatorial polity. First, it is fair to argue that the power of the dictatorial polity stemmed from the continuity of institutional arrangements (e.g., regulations, incentives), strategies (e.g., plans, colonisation-and-development approaches) and state organisations (e.g., Water Authorities). These were not exclusive of Franco's dictatorship, but actual entities that can be traced back throughout the different polities of the entire 20th century, which determined the reproduction of vested political interests in the public support of hydraulic infrastructure, subordinated rhetorically to the interest of the nation.

Second, I argue that the effect of the reformism of the II Republic is difficult to assess owing to its fleeting duration. In particular, the potential role of its Water Authorities, which were purportedly more transparent, flexible and democratic, did not have time to produce measurable results in the development of irrigation agriculture and hydraulic infrastructure. Even so, irrigation agriculture in the Low Guadalquivir advanced at an unprecedented rate along this period, backed by a Plan for the Expansion of Irrigation elaborated prior to it, in 1930 (Fernández 2000). Moreover, it is argued that the hydraulic-paradigm forcefully promulgated by Joaquín Costa at the outset of the 20th century, reached maximum validity and operational implementation between 1926 and 1936 (Díaz-Marta 1989, p. 21) – although through a deep agrarian and property reform characteristic of leftist polities.

Third, there is a factor not analysed in this thesis that had played a fundamental role in the development of hydraulic infrastructure along the first decades of the 20th century: the enormous drive of the hydroelectric sector, supported primarily bottom-up from the private initiative, which determined strongly the construction of large primary infrastructures, low-efficient for irrigation purposes (see e.g., Mateu 2000).

Fourth, the progressive liberalisation of the agricultural sector during the second half of the 20th century was decisive for the modernisation of Doñana's rice agriculture and its

entry in the global market. This is something that could have arguably occurred under the auspices of a diversity of polity forms. Moreover, it was probably delayed until the 1970s by the persistence of the autarchic policies of the dictatorial regime.

Finally, it is arguably true that the initial development of rice agriculture strongly depended on: (1) the carte-blanche given by Franco's government to Beca for the initiation and posterior success of rice development, favouring the establishment of a monopoly; (2) a large low-to-no wage labour force, originating from a combination of unwaged prisoners of war and low-waged employees (resulting from the high unemployment and the virtual absence of labour rights characterising, respectively, the pre- and post-war periods). However, the development of rice agriculture benefited from structural and discursive factors of previous periods. For example, it benefited from the road and rail network and hydraulic infrastructure pre-existing on the ground, from the previous transformative attempts of other companies. More interestingly, the hydraulic works developed by the company of Beca during the 1940s and 1950s (Table 16) were contracted by the central government and publicly funded, backed by the Gasset Act of 1911 (Ojeda-Rivera and Moral-Ituarte 2004, p. 34). In other words, that works were supported by probably the most representative institutional landmark of the material-reconstruction, hydraulic-irrigationist rhetoric of the regenerationist dream during the Restoration period. I argue that the intrinsic features of the entrepreneurship component, i.e. of Beca as an entrepreneur and the know-how of the Valencian rice growers, were more determinant for the development of rice agriculture than the form of the polity. In other words, while the role of the entrepreneurship component, an endogenous condition, was necessary for a satisfactory causal explanation of the Doñana's rigid outcome, the form of the polity, a contextual condition, was not. Although the occurrence of the entrepreneurship component was probably advanced by the authoritarianism of the dictatorial regime, such event could have arguably occurred under the auspices of a diversity of polity forms. Moreover, by way of counterfactual, I argue that had an entrepreneur like Beca not attracted a workforce like the Valencian rice-growers, which provided a culture and know-how indispensable for the development of rice agriculture in the Guadalquivir marshlands, it was very likely that such agriculture would have not fully developed.

In sum, although I cannot be conclusive from my case, it seems that the huge transformations of the second half of the 20th century in Doñana have supervened on institutional, discursive and entrepreneurial mechanisms. In that sense, although those mechanisms were related to political and power factors, the transformations have not depended on the specific form of the polity. If something, it can be argued that the grandiose and speculative assumptions and ideas of the highly inertial HIR discourse reached their maximum splendour on the ground, under the auspices of an opportunistic dictatorship, which accelerated implementation through highly-centralised technocratic organisations and developmental planning (Development Plans of 1964-1967, 1968-1971, 1972-1975) (Moral-Ituarte 1991, p. 511, López-Gunn 2009, p. 373). I will, however, argue that it was a 'structural accident' waiting to happen. Its end was marked by infrastructural saturation and the realisation of the impossibility of managing an overwhelming water demand, thus turning into a 'hydrological paradigm' (water supply management) in the 1990s. Such paradigm adopted a more holistic rhetoric, but it nevertheless waxed lyrical over the regenerationist dream of Joaquín Costa and kept a hydraulic mark in its promotion of large water diversions (Table 16). Along the process, the HIR discourse had an enormous ideological power that originated during the 19th century and was institutionalised along the Restoration period, independently of the governing party (liberal or conservationist). Afterwards, the HIR discourse paved its way towards the ensuing periods, embedded in the institutional matrix, at the legislative, strategic and operational levels. In turn, the institutional matrix produced regularised expectations and patterns of interaction among collective-action actors, due to the increasing returns that it signalled downstream of the constitutional level. Such actors were responding to opportunities and constraints that were socially shaped, embedded in the institutional framework and cognitively powerful; i.e. they were not just merely responding to external, incentives of unknown origin.

At the national level, it can be argued that both hydraulic development and the irrigationist culture would have been improbable without the presence of a discourse deeply structuring the consciousness and view of reality of all-level actors. This, in turn, constrained their choices, practices, courses of action and ways of solving problems; and, to a great extent, legitimated the institutions under development, thus limiting their possibilities for transformative agency. Borrowing from Schwartz (2004, p. 8), the local events and behaviours occurring in Doñana during both the increasing-returns and self-

reinforcement phases, which neoclassical economics would assess as random, irrational or illogical, were in fact "specific manifestations of larger structural forces". Other authors' interpretations also support the argument that the HIR discourse exerted a powerful influence during the whole 20th century, as a highly effective panacea creating a logical vortex capable to absorb a diversity of political and socioeconomic interests and, more generally, ideologies (see e.g., Moral-Ituarte 1991, p. 463, Moral-Ituarte 2009). Its power relied in its capacity to legitimise the idea of irrigation agriculture and hydraulic works as the nationwide remedy for economic development and prosperity, underpinned by: "a decidedly political strategy, a particular ideological vision, a call for a scientific-positivist understanding of the natural world, a scientific-technocratic engineering mission, and a popular base rooted in a traditional peasant rural culture" (Swyngedouw 1999, p. 453). Water appeared as a resource with "instrumental value in power struggles at different geographical scales", in the process of progressive decentralisation of management that took place in Spain during the 20th century (López-Gunn 2009, p. 370). Of course, in the Doñana case, the devil's advocate argument would be that, had the action-reaction chain of events unfolded in a different order or within a different polity, we might be currently facing a totally different outcome, either with no natural assets left, i.e. a lock-in trap, or with a larger portion of the original marshland ecosystem protected.

In sum, this section has shown how, by informing analysis through additional conceptual layers, the Doñana's rigid outcome is more predictable and less subjected to contingency, i.e. how contingency can be modulated. Both the path followed by the institutional regime for water resources management and the systemic rigidity trap can be more easily determined if the epistemological device of the investigation is enriched. Nevertheless, in any case, whatever the theory is used to evaluate institutional path dependence and contingency, it requires an elaborated argumentation inseparable of theory, i.e. path dependence is always a theory-laden concept, and cannot be understood and justified outside its epistemological device.

7.2. Escaping the rigidity trap in Doñana

Insights from theory on maladaptive traps have unveiled several alternative states around which the Doñana water socio-ecosystem could have tended, after the first

critical juncture (CJ1). Of them, two are currently relevant, since they are still reachable in the future (see Fig. 21): (1) the "lock-in trap" (Allison and Hobbs 2004), which is sub-optimal than and adjacent to the current rigidity trap, and would entail – in fact it would be caused by – the continuity of the rigid institutional regime; (2) a more desirable phase of institutional learning and innovation based on more flexible and adaptive approaches to policy and decision making. Historically, the latter state would have been intermediate between the original utopian option of 'doing nothing', and the actualised option that gave rise to the current rigidity trap. However, any discussion about sub-optimal outcomes should not be centred on unproductive debates of regretting the past, but rather focus on debates facilitating a better future (Schwartz 2004).

Indeed, the rigidity trap implies that the Doñana water socio-ecosystem retains a high potential for change in the form of natural capital and assets such as the Doñana Nature Reserve and the rice fields, the latter constituting "an alternative habitat for waterbirds and provide food and shelter for many avian species" (Toral and Figuerola 2010). Based on the insight of the innovative capacity and action of certain actors in Doñana (e.g., the Valencians, the Ω-α group led by Valverde), it is my contention that such potential can be still steered, normatively, into a transition that push Doñana into a future outcome dominated by institutional learning and innovation. Moreover, although the option of 'doing nothing' was definitively precluded during the 1950s-60s, such transition should offer space for the preservation of traditional ecological knowledge (Gómez-Baggethun 2012) – a knowledge that is being lost at a worrying rate. My core assumption here is that the potential attractors foreseen by the adaptive cycle are neither static nor the end of history. They are dynamic and allow actors for breakout though agency and ingenuity (e.g., policy networks, institutional entrepreneurship), for undermining the 'inherent logic' of the system, and for overcoming the structural constraints of their immediate past (e.g., infrastructure, maladaptive institutions). In sum, although the past linked decision making through time and largely determined the choice set in Doñana (sensu North 1990a, pp. 98-99), the rigidity trap is only as constraining and escapable situation whose temporality must be well specified. It doesn't traduce in irreversibility thanks to the traditional ecological knowledge and natural capital retained, which may provide a way out to a more sustainable outcome that captures alternative values to intensive economic development, thus a possibility for breakout.

7.3. Insights from the action-research program

Extensive research on how participatory methods can be used to achieve desired outcomes in water resources management is relatively recent, and understanding the process of involving and engaging multiple actors with divergent goals in a participatory process, still remains a challenge (Daniell et al. 2010). I examined and informed this concern through an assessment of the action-research program in the Doñana Nature Reserve. In that program, pre-existing knowledge on the Doñana case (by part of the action-research team) and the historical institutional assessment (Chapter 4, Section 4.3.1) led to the identification of a set of rigidities within the political, institutional and organisational realms in Doñana. This realisation furthered the idea to use action research for introducing innovative approaches, such as the tenets of adaptive management, at the research-management interface as 'external insiders'. Retrospectively, the safe-to-fail experimental approach carried out in the Caracoles estate (Doñana 2005 Project) constituted a crucial, novel approach that made use of a short-lived opportunity window, and attempted to both generate a sound ecological understanding of wetland functioning and introduce new modes of water resources management and wetland conservation based on adaptive management. However, the approach faced considerable resistance at the collective-choice and operational levels. Coinciding with the transfer of competence on the management of the Doñana Nature Reserve from the national to the regional authorities (i.e. the re-opening of a new constitutional phase), the Caracoles estate restoration works were temporarily halted and the timing of its implementation substantially modified. Indeed, the realisation that even "humble" interventions aimed at proving the usefulness of new approaches could face both resistance at higher decision-making levels and considerable uncertainties in the socio-political realm, reinforced the team's perception of the importance of action-research programs such as the one presented in Chapter 4.

The main contribution of the program, however, was not the initiation of a process of change towards the implementation of adaptive management tenets for water resources management and wetland conservation in the Reserve. Rather, it was its valuable role in highlighting the possibility to introduce small changes and innovations based on adaptive management tenets at the research-management interface through a step-wise process of actor (decision makers and stakeholders) involvement designed thoroughly

and transparently. This result is particularly valuable given the rigid institutional arrangements and organisational structures identified through the preliminary historical assessment. The approach showed particularly useful for building the necessary trust both in the action-research team and the objectives of the program. This statement is based on the assessment of the level of trust against the wide participation in the process, the diversity of participants in the research-management workshop and the ample agreement on the policy recommendations collaboratively developed at that workshop.

For the purpose of organising and implementing the action-research program, and for the collective determination of the recommendations, the experience gained in Canada on adaptive management was critical; in particular, that relating to the processes of stakeholder involvement and collectively framing problems through the creation of a mutual learning space. Thinking as 'adaptive managers' was invaluable for anticipating those issues, as well as for navigating a complex process along which the underlying causes of deeply entrenched problems were challenged and alternative visions and trade-offs were debated. The experience in Canada allowed us to deductively pose upfront critical problems that the institutional regime was facing (e.g., lack of shared, collectively chosen management goals), thereby informing and structuring the process based on scientific guidance. Based on the Canadian experience, it is also my personal opinion that, although perchance ephemerally, we were also successful in watering down power distances between the executive and operational staff functions, and that all participants had the opportunity to express their perspectives about the issues addressed during the workshop. Therefore, I argue that the successful application of a true participatory and pluralistic approach ensured that no actor benefited more than others from the process.

Overall, that the action-research program constituted a robust (although not unique) strategy for triggering actor involvement and for introducing certain improvements in water resources management and wetland conservation policies in a rigid institutional regime facing high institutional uncertainty and the legacy of entrenched historical conflicts. Allegedly, the whole program and the recommendations collectively produced, which departed from the summary of main lessons learned in Canada, helped the research team in its intent to intervene as internal agents of change acting externally.

In particular, the team overcame a series of uncertainties and historical conflicts that the Doñana faces at the institutional and organisational levels, largely rooted in the intrinsic rigidity inherited from its historical trajectory. However, as the institutional analyses show, historical events reflect a broad array of causal, uncertain relationships in the outcome institutional configuration of Doñana. Such realisation stresses the importance of understanding the history of the current institutional conflicts, for the double purpose of: (1) understanding, analysing and involving actors; (2) preparing successful participatory activities that help overcoming locked or hidden conflicts and mistrust.

In my view, the recurrence of command-and-control schemes for water resources management and wetland conservation has contributed greatly to the stabilisation of rigidities within the Doñana institutional regime, hence increasing the chance of new social crises and institutional conflicts. These conflicts, in turn, have further exacerbated the network of distrust and lack of shared expectations. The build-up of conflicts locked into a rigid institutional regime is probably hindering the effective implementation of alternative management strategies for water resources management and wetland conservation nowadays, thus depriving local stewards and societies from the opportunity to innovate.

7.4. Implications of the research within an European institutional context

The institutional analyses and the insight gained from the action-research program suggest that the statutory backing of the European Union's Water Framework Directive (WFD) could provide the momentum needed for an innovative change in the Doñana water socio-ecosystem. For example, one of the conclusions of the research-management workshop was the need to draw specific plans for the wider catchment area influencing the Doñana Nature Reserve, complemented by the separate delimitation of the sub-basin (with a specific management plan) directly influencing the Doñana marshland/wetland ecosystems. Article 13.5 of the WFD states that River Basin Management Plans may be supplemented by the production of more detailed programmes and management plans for sub-basins, to deal with particular aspects of water management. The directive also requires special attention to protected areas, which have to be registered (Article 6 and Annex IV) and covered by adequate monitoring programmes (Article 8).

Furthermore, participatory processes similar to those described in this article could become the cornerstone of the process of public information and consultation required by Article 14, in the spirit of widening participation proposed by the WFD guidelines (WFD CIS 2003). This reasoning could be generalised to comparable cases governed through rigid institutional regimes, in which key protected nature reserves including wetlands are important elements of a river basin. The mentioned participatory processes could provide both a solid interface with a whole range of stakeholders, and a platform for the dynamic interaction between research and management. These and other requirements of the WFD reflect a growing realisation of the importance of combining short-term management actions with long term sustainable goals, using surrogates of ecosystem quality to monitor the progress, and encouraging novel processes of public participation like social learning. The implementation of adaptive strategies that allow for the sustainable management of natural resources, the environment, and complex socio-ecosystems using imperfect knowledge, is a cornerstone in the modernisation of EU environmental policy. Indeed, the WFD does not encourage adaptive management, but it does not preclude it either. One could even argue that it implicitly embraces it, as a strategy that intrinsically promotes and entails social learning.

However, the WFD also shows the persistence of outdated management procedures and the fear of management institutions to let their knowledge (and in particular their *modus operandi*) to evolve, thus making efforts to make the system adaptive and accountable rather weak. Social learning and learning-by-doing attempts are also likely to encounter the resistance of scientists, managers and policy makers, stemming from their respective institutional cultures. These drive managers and policy makers to mistrust researchers (since they often tend to fear uncertainty and resent exposure to public debate), and scientist to mistrust managers and policy makers (since they are often not willing to have their findings questioned on what they perceive as opportunistic considerations, such as allocation of funds, political opportunity or institutional viability).

The results of the TRANSAM project suggested that such resistances might stem from a fundamental difference in the way in which the European and North American societies and administrations have approached the controversy surrounding the interaction between economic development, human welfare and environmental quality. In the USA

and Canada, a vivid public debate involved all major actors and forced them to work hard into achieving a consensus and communicating it effectively to the public. On the one hand, such debate guaranteed a continuous re-evaluation of officially-held positions by all parties, well in agreement with the spirit of adaptive management. On the other hand, the implementation of environmentally responsible schemes has been held by corporate inertia, which can exert very active lobbying pressures against environmental regulations, and by the difficulties in mainstreaming existing officials into new management ideas.

In the European Union, the centralist tradition of most member states and the European Commission itself has prevented a full-winged public debate. Environmental regulations and complex management systems are being effectively implemented; however, they are very hierarchical and rigid, and give little room to adaptive schemes. In particular, the profound fear of public scrutiny and criticism at both national and European level is blocking any significant evaluation of the role played by current "mainstream thinking" in determining the achievements and failures of the environmental policy of the European Union. In addition, increased control over research funding has been used to mainstream research upon pre-determined directions, at the price of preventing innovation and curtailing the generation of debate and criticism. Since their policy documents abound in references to public participation, democratisation, adaptation, innovation and interdisciplinarity, it seems fair to conclude that the roots of the problem lay in the institutional framework and management culture rather than in the ultimate intentions of European Union's policy makers. The atomisation of national academies, which seem unable to organise themselves at a European level and generate a satisfactory consensus on any polemic environmental issue, has worsened the process significantly. All of this is particularly unfortunate, since the implementation of environmentally-responsible, adaptive management schemes will require major institutional changes at both European and national levels, and the European Commission is probably the only institution with the capacity to mainstream scientists and local managers towards the required levels of scientific and professional innovation.

This study shows how, in rigid institutional regimes in general, small-scale initiatives that increase institutional flexibility and facilitate the build-up of trust must precede any attempt to implement truly innovative schemes such as adaptive management.

Therefore, the preparatory work by agents of change to increase institutional flexibility and build trust, such as the one performed in the action-research program presented here, will probably be a necessary step to fully implement some of the most innovative aims of the current European Union's water policy (e.g., participation requirement, good-ecological-status aims of the WFD). However, as the Canadian experience with adaptive management shows, the successful adoption and institutionalisation of adaptive management, i.e. of innovative approaches to participation and management, requires the convergence of several, critical (organisational, socioeconomic, conceptual and legal) factors, particularly when the social-ecological systems involved face complex dynamics, uncertainty, and socio-institutional and political conflicts. In Canada and elsewhere, such as the USA and Australia, such convergence has been transitional, and it required the build-up of knowledge and experience by at least two generations of adaptive-management theorists and practitioners. In order to address the increasingly urgent, uncertain, and complex environmental problems facing the European Union, the European Commission should mainstream scientists and local managers towards the required levels of institutional, scientific and professional innovation required for the implementation of adaptive strategies and other innovations. This process might be speeded up using the experience of other regions around the world.

7.5. Main methodological limitations of the research

The main limitations of this research can be probably found at the methodological level. Although a qualitative design allowed me to examine the Doñana case in depth, the collection, analysis and interpretation of data has been time consuming, including the characterisation of findings in a visual way. It has also required a great deal of training for which I have not found useful support (e.g., specialised courses on systems thinking or discourse analysis) beyond the valuable help and experience of my supervisors.

Another limitation is the degree to which my findings can be generalised. As argued in Chapter 2, the main strength of my single-case study approach is that results can be generalised to theory, in an 'analytical generalisation' fashion. But the generalisation of my findings to other cases is necessarily limited. However, since the principles of neoclassical economics are universalistic in nature, my methodological approach and theoretic-analytical questions justify their direct application in other cases and warrant

the achievement of significant results with both empirical and theoretical significance. 'Literal replication' would be accomplished if identical results were obtained over multiple cases, stating more assertively cross-case results; 'theoretical replication' would be accomplished if the same results fail to occur in a second group of cases, but the initial result of my case study would then stand more robustly, due to their particular character (Yin 2009, p. 140).

A last limitation of my (qualitative) research is related to its heavy reliance on complex systems thinking through its application in both the historical systems narrative in Chapter 5 and the explanation building in Chapter 6. Complex systems thinking reflect social-ecological phenomena that cannot be captured by other methods, such as quantitative methods in general (e.g., econometric tests) or approaches based on methodological individualism (e.g., rational models of the actor). However, those two methodological approaches provide the analyst with deeper understanding of correlations between variables in relevant processes, such as demographic trends and changes in property regimes. A better understanding of these types of processes might reveal causal powers with great effect on observed outcomes that perhaps was not captured with a way of narrative thinking that focus on complex relationships and patterns, and on emergent phenomena. Indeed, the combination of narratives conveying the use of historical qualitative evidence with quantitative methods can be a powerful tool in institutional analysis (see Alston 2008).

7.6. Lessons learnt and directions of further research

To discuss optimality criteria in the context of path dependence and neoclassical economics is important for two main reasons. On the one hand, neoclassical principles are still uncritically mainstreamed in current governance in many sectors, determining, to a great extent, policy and institutional practice. Such principles obviate, by default, the complex and uncertain dynamics of social-ecological systems, as well as the role of politics and power in the determination of efficiency and optimality standards. On the other hand, there is the pedagogic character of path dependence and its neoclassical economics core. The value of path dependence lies in its heuristic power for normative purposes. In particular, it lies in the concern with the risk of lock-in of structural components (e.g., technologies, institutions, paradigms) in the presence, for example, of

large set-up, sunk or transaction costs, hence with institutional inertia and the irreversibility of changes made to the biophysical conditions. While it is certain that the path-dependent character of a given historical process can be only assessed ex post, an enhanced theoretic-analytical and predictive capacity (i.e. better modulated contingency) could perhaps be useful in offering better policy prescriptions and institutional designs ex ante. The improved understanding of current, seemingly random institutional or ecological occurrences would entail the improvement of our present scientific tools, as well as, more pragmatically, an early awareness of behaviours or events that might signal the imminent fall of a given social-ecological system into an undesirable outcome bearing high opportunity costs (e.g., lock-in traps). In my view, contingency reflects, in some cases, a failure in either our current understanding of how causal processes work, or the general assumptions and principles that we establish (e.g., as the foundations of neoclassical economics), but neither precludes explanation nor impedes theoretical and knowledge advancements. After all, "without contingency, alternative paths would be known ex ante and there would be no unpredictable outcome" (Vergne and Durand 2010, p. 753).

Contingency, as conceived above, can turn into a modulable epistemic heuristic that may help the researcher to assess ex ante whether the phenomena under analysis is the consequence of random event or behaviour, or an outcome that could be better predicted through an enhancement of the epistemological device at work. Contingency may also fulfil a more complete role if used to assess all the genetic, self-reinforcing and lock-in phases of a hypothesised path-dependent pattern, thus allowing the researcher to classify a broader set of mechanisms. I do not argue that randomness might ever be exhausted. Contingency, as conceived in this thesis, warns the researcher that premature assessments of randomness might render in futile endeavours, since a simple theoretical leap can shed light onto the inexplicable and turn it into something more predictable. And, since hundreds of theories are at our avail, such leaps are neither unattainable nor complex; they are just complicated to justify, but manageable if treated with care and parsimony.

I am raising these issues here not so much because I think that they went unnoticed in the literature, but to emphasise their relevance for future studies. I believe that a conceptual movement of this type would undoubtedly contribute to the generation of

comprehensive explanations accounting for the most probable constellations of factors producing broader sets of outcomes. Indeed, if the outcome under analysis (in my case, a rigidified outcome) is clearly defined and the causal mechanisms (e.g., network effects, increasingly shared cognitions) are made explicit at multiple analytical levels, path dependence turns into a potent explanatory concept (see Dobusch and Schüßler 2012). For North (1990a, p. 112) the promise of path dependence is that "it extends the most constructive building blocks of neoclassical theory" (e.g., incentives as the driving force), but "modifies that theory by incorporating incomplete information and subjective models of reality and the increasing returns characteristic of institutions". Finally, I also believe in the useful contribution of current, neoclassical efficiency and optimality criteria for policy prescription and institutional design. Such criteria, in their welfare version (e.g., Pareto efficiency; see e.g., Brock et al. 2012 for its analysis in social-ecological systems), project a future world in which the allocation of resources is more efficient and doesn't leave anyone worse off, i.e. no individual actor fails to maximise their given preferences, from a given set of initial conditions. Different questions are the legitimacy of such preferences, how to aggregate them in policy calculations and whether, without frictions from the polity, the socioeconomic object under study (e.g., the market) self-regulates or not. All of these latter questions are out of the scope of this thesis.

For me, an urgent direction of further basic research, implying applications informing the development of optimality prescriptions in social-ecological systems, should include the blending of path dependence and its neoclassical core in a unique heuristic. The latter, in turn, should be contextualised in modern neo-institutionalist insight and resilience theory, the latter accounting for the complexity and uncertainty associated to these social-ecological systems. These advancements must be backed by empirical research accounts emerging from systematic, comparative historical studies that integrate multi-level components, indicators or variables, in the way the IAD and its extended version, the p-IAD, do, in order to account, in an integrated manner, for multiple phenomena. For successful systematisations and more productive debates, research must be explicit in its conceptualisation of contingency, efficiency, optimality and rationality assumptions. Another important element is the integration of an entrepreneurial component into analytical frameworks, in order to augment the capacity of such frameworks to analyse and diagnose human action and agency under uncertainty

(see e.g., Westley et al. 2013). This type of systematisations might enhance (1) the forecast of traps, all of which are foreseen and well-characterised by resilience theory, but are currently unpredictable on the basis of genetic and process conditions; (2) our capacity to inform the general prescription of the need to replace, during transitions, blueprint panaceas (such as the traditional command-and-control paradigm or other), by the adaptive paradigm. The traditional and static logical core of both neoclassical economics and the command-and-control paradigm is ill-equipped to deal with a dynamic world characterised both by ubiquitous uncertainty and by entities much more complex than the isolated social and socioeconomic systems portrayed by reductionist models.

In the Doñana case, future research should include, in an inward-outward fashion, the water problems related to increasing demand for tourism and irrigated agriculture (e.g., strawberry cultivation); the problems related to the dredging of the estuary for enhancing navigability; and the challenges posed by accelerated development in the area of socioeconomic influence. Such research should ideally allow for a step-wise approach to the multi-level and multi-scale, policy and institutional complexities involved. The general question could be: how a sustainable future can be navigated independently of history? It could explore potential paths and outcomes, such as the implementation of participatory, adaptive and transparent polycentric governance allowing actors to learn from the past (i.e. without top-down, command-and-control authoritarian impositions). In particular, based on the lessons learned from my case, I wonder whether changes in the productive elements of discursive factors (e.g., arguments, narratives) could trigger more profound changes in institutional structures that facilitate a transition towards a more adaptive and flexible paradigm, i.e. whether discourses can change the institutional architecture at the core of governances!

Chapter 8. Conclusion: Overview of the major findings by objective

This thesis departed from a grand tour question: What are the main institutional opportunities and constraints for the development of more flexible and adaptive approaches for water resources management and wetland conservation in the Doñana region? Based on that question, the main aim of the thesis was stated as follows: To understand and explain the main institutional opportunities and constraints for the implementation of adaptive governance and management in the Doñana region, with a specific focus on (1) its institutional regime for water resources management and wetland conservation, and (2) the research-management interface.

To address this aim, the study was divided into 5 specific objectives. As stated in Chapter 1, Section 1.4, objectives 1 and 2 corresponded with the action-research program carried out in Doñana. Objectives 3 and 4 corresponded with the institutional analyses. In general, the historical institutional assessment presented in Chapter 4 and the preliminary versions of the historical systems narrative presented in Chapter 5 fulfilled the objective to inform the action-research program. In turn, the insight gained through that program was very useful in the design of the institutional analyses. In this chapter, I summarise the key results of the study, relating them to the specific objectives. Then, in Chapter 9 I turn to a formulation of guidance and a series of recommendations on potential policies and institutional designs for a process of change towards more flexible and adaptive approaches for governance and management in Doñana.

8.1. Realisation of objective 1

Objective 1 was stated as follows: to learn from best-in-class practitioners on adaptive management from British Columbia (Canada), in order to support the implementation of the action-research program described in the next objective.

Chapter 3 has described a research carried out in British Columbia (Canada) through which the team of the TRANSAM project learned about the Canadian experience on adaptive management. The lessons learnt in that research served to support the action-research program developed in the Doñana region. The main conclusions of that research were:

- In British Columbia (Canada), adaptive management (AM) has cycled during the last four decades through alternate phases of theoretical development, practical implementation and feedback (public workshops and debate), to which many scholars and practitioners have contributed.
- This process has provided AM theorists and practitioners in the fields of natural resources management and nature conservation with a complete and diverse body of knowledge on the subject (AM body of knowledge, AMBoK hereafter).
- Along history, the practical implementation of AM in Canada has faced a number of institutional opportunities and constraints. At the constitutional level, the institutional regime for natural resources management and nature conservation was characterised by a continuous trial of strength between the federal and the provincial governments, with a legacy that has endured to date. Indeed, during the last decades, the provincial and municipal governments have progressively increased their stewardship powers and duties over management and conservation – leading also to processes of institutional (i.e. organisational, legal and scientific-technical) convergence and coherence in some socioeconomic sectors (e.g., forest sector).
- In the Clayoquot Sound, the process of de-centralisation and institutional convergence represented a necessary step that empowered the BC Government to introduce, from the top, key institutional innovations (e.g., the creation of the Scientific Panel for Sustainable Forest Practices, SPSFP). At the collective-choice and operational level, the work of the SPSFP in the Clayoquot Sound revealed that the successful adoption and institutionalisation of AM required the convergence of several organisational, socioeconomic, conceptual and legal factors. The number of factors involved was considerably large because the social-ecological system faced a great deal of complexity, uncertainty and historical conflicts. The successful implementation of AM initiatives at the Clayoquot Sound and its

surroundings (e.g., Vancouver Island, BC Coast) was made possible by the availability of an the AMBoK, which had been previously developed and evaluated at a number of small, pilot projects and sites in Canada and the USA.

- An additional key factor was the bottom-up *"successful, strategic, cooperation between academics and actors from the (forest) industry, willing to test alternatives to contemporary resource management and economic development strategies"* (Fred Bunnell, quote from the workshop). Such factors were established formally and collectively by a diverse group of key regional actors (researchers, managers, foresters, socioeconomic agents and local communities), in a platform based on AM tenets.
- The "avant-garde nature" of the concept required a sustained effort for the collective understanding and agreement of its usefulness, and an institutional transition towards a more flexible, open-knowledge-based, and learning institutional regime.
- Such transition was also the result of a socioeconomic and ecological crisis (the so-called 'logging crisis'). This crisis constituted a historical event weighed down with uncertainty that was sufficient (but not necessary, nor unique) to trigger institutional change and innovation in the region.
- The Vancouver workshop allowed for eliciting current opportunities and constraints for the testing and implementation of AM in Canada, based on the direct, on-the-ground experience of practitioners and analysts.

8.2. Realisation of objective 2

Objective 2 was stated as follows: to explore the instrumentality of action research for facilitating stakeholder involvement in current and future implementations of adaptive management in the Doñana region, with a particular focus on the research-management interface.

The action-research program has been described in Chapter 4. The program paralleled the adaptive management initiative at Caracoles. To inform the program, I undertook an extensive historical institutional assessment of the Doñana region, which also allowed me to a priori identify potential opportunities and constraints for introducing

innovations at research-management interface. The process designed to undertake the interviews and the workshops, which included a formalised process of networking, focus groups and System Dynamics techniques, proved very useful to engage and build trust among the actors that finally participated in the workshops. The most significant expression of that trust is the high-profile policy recommendations developed by the participants in a collaborative way. These recommendations offer potential avenues to improve water resources management and wetland conservation in the region, based on adaptive management tenets. They have been used to ground the formulation of policy guidance and recommendations offered in Chapter 9. The main conclusions of the action-research program were:

- The results of the historical institutional assessment pointed to the persistence of institutional rigidities for water resources management and wetland conservation in the Doñana Nature Reserve, in particular, and in the Doñana region, in general.
- In such context, the use of an action-research program based on the assessment of the Canadian institutional experience with adaptive management and the AMBoK, was instrumental in loosening rigid organisational structures in Doñana.
- The action-research program served, in particular, the long-term purpose of proactively engaging the actors directly concerned with decision-making in a joint research-and-learning process, aimed at facilitating future implementations of flexible and innovative approaches such as adaptive management.
- The results of this research stage suggest that any attempt to introduce participatory strategies in rigid institutional configurations must be preceded by preparatory work by agents of change, in order to increase organisational flexibility and involve a wide-range of stakeholders.
- The combination of methods used (interviews, focus groups and Group Model Building in workshops) constituted a powerful tool to identify and develop, informally and collectively, unexpressed ideas that had remained tacit but were broadly accepted, on issues that hinder the potential for the resolution of key problems and broader conflicts (e.g., the existence of large power distances between individuals within and between research and management agencies).
- It is also worth noting that action-research initiatives represent a demanding task requiring updated knowledge about the case study, *in situ* social capital, strong

commitment, resilience to short-term failure and considerable social/emotional skills – particularly since those involved in them usually enter a locked conflict as "external insiders", and must navigate the risk of being involuntarily involved in the conflict among the different actors.

8.3. Realisation of objectives 3 and 4

Given my mode of thinking and inference procedure (see Chapter 2, Section 2.4), which are based on complex systems thinking, objectives 3 and 4 are inseparable. They have been fulfilled jointly through the analyses carried out in Chapters 5 and 6, and through the discussion of results offered in Chapter 7. Objectives 3 and 4 were stated as follows:

- Objective 3: to understand and explain the historical genesis (origin, operation and evolution) of the institutional regime for water resources management and wetland conservation of the Doñana region, assessing, in particular, the causal weight of history in the regime's current rigid configuration.
- Objective 4: to understand and explain the mechanisms stabilising the regime around its current rigid configuration.

Chapter 5, building on the historical institutional assessment presented in Chapter 4, has presented a deeper historical analysis delving into the origins and development of the Doñana's institutional regime for water resources management and wetland conservation. The resulting explanation has two distinguishable parts. On one side, the deep-historical genesis of the regime at a critical juncture in the 19th century; on the other, the regime's formation and continuity up to the last decades of the 20th century, despite its dysfunctionality for coping with crisis and its inability to harmonise wetland conservation, water management and economic development. Afterwards, Chapter 6 has offered an account challenging the outcome of the previous analysis in an deeper study about the role of discourses and entrepreneurship in their relationship with politics, institutions and power, as factors contributing to the formation of the Doñana's rigid outcome. As a whole, the main conclusions of those research stages were:

- The explanation included in the historical pattern has two distinguishable parts. On one side, the deep-historical genesis of the regime at a critical juncture in the 19th century. On the other, the regime's formation and continuity up to the last decades of the 20th century, despite its dysfunctionality for coping with crisis and its inability to harmonise wetland conservation, water management and economic development.
- The whole explanation allows to preliminarily evaluate the hypothesis (h_1) that the Doñana's regime has followed a path-dependent dynamic, largely characterised by the historical recurrence on the application of command-and-control policy panaceas.
- In a seeming paradox, these panaceas, instead of driving the regime towards an efficient outcome, led to the formation of a rigid institutional regime that drove the whole water socio-ecosystem into a sub-optimal systemic rigidity trap.
- Through the magnifying lenses of the theory on institutional path dependence, this rigid outcome is qualified by theory as unexpected (i.e. contingent), for it defies the traditional expectations of neoclassical economics that lie at the logical core of the concept of such theory.
- The second theoretical iteration, through which I re-examined the historical pattern and the causal, path-dependent mechanism posited by hypothesis h_1 of the thesis, has shown how the Doñana's rigid outcome is more expected to occur if a more comprehensive analytical framework is used, in this case, the p-IAD.
- In the Doñana water socio-ecosystem, I argue that three mechanisms were necessary and sufficient conditions for the transformational process that led to the Doñana's rigid outcome: (1) a contextual political-discursive mechanism that mobilised power top-down and signalled increasing returns to actors downstream of the institutional regime; (2) the operation of increasing returns and self-reinforcing mechanisms bottom-up; (3) an endogenous entrepreneurial component that acted as a mechanism for action in an environment of extreme uncertainty.
- The investigation of political, discursive and power contextual factors, guided by the p-IAD, proved instrumental to unveil these mechanisms, shedding light over the components determining the Doñana outcome.
- This type of investigations may help in avoiding premature assessments of local randomness and, through the use of enhanced epistemological devices, it might shed light on upper, structural factors that constrain decision and action downstream.

- In the general discussion of the thesis (Chapter 7), I have then made the case for systematising the role of discourses and entrepreneurship factors in their relationship with political-economic and power into the analysis, for diminishing the degree of contingency associated to the Doñana's rigid outcome.
- Complemented by Section 7.6 on lessons learnt and directions of further research, my discussion has dealt with contingency as a property of the concept of path dependence that can be modulated in explanations of institutional dynamics in social-ecological systems. This type of advancements would contribute to increase our capacity to predict the likelihood of certain types of outcomes.
- In turn, this would help in better informing future policy and institutional designs for successful transitions towards adaptive governance and management in social-ecological systems, hence improving the prospects for the more sustainable use of natural resources and ecosystems.

8.4. Realisation of objective 5

Objective 5 was stated as follows: to develop policy guidance and recommendations for future implementations of more flexible, participatory and adaptive approaches for water resources management and wetland conservation at the governance and management levels in the Doñana region, based on the results of the research.

Next chapter (Chapter 9) includes policy guidance and recommendations on a potential process of change towards adaptive governance and management in the Doñana region. The elaboration of the guidance and recommendations has been informed by the results, discussion and conclusion of the research. Special attention has been given to the seven recommendations elaborated collaboratively by the participants of the research-management workshop of the action-research program.

Chapter 9. Policy guidance and recommendations for a transition towards adaptive governance and management in the Doñana region

Based on the findings of the case study, in particular the recommendations elaborated collaboratively by the participants of the research-management workshop during the action-research program, the following recommendations have been identified:

1. **Establish an executive mandate for the development of a governance strategy addressing, in an integrated way, the current institutional, socioeconomic and environmental problems faced by the Doñana coupled social and ecological system, and incorporating the different values, interests and knowledge of all its stakeholders.** Such an strategy should:

- ***Foster adaptive governance*** as a collaborative, context-specific approach that relies on the integration of scientific, local and traditional knowledge to facilitate the engagement of local communities and stakeholders with government in the participatory design and implementation of policies.
- ***Set overarching goals*** collaboratively with stakeholders, relying on participatory mechanisms and adaptive approaches (see below for details), and use them to develop clear measures of success that are gauged and reported along the implementation of the strategy.
- ***Strive for cross-sectoral and multi-scale analysis*** to identify emergent problems, to link decision making and regulatory changes, and to integrate policy implementation across sectors, taking into account other relevant policy areas such as climate change.
- ***The environmental, ecological and socioeconomic importance of the ecosystems of Doñana should be established as a key principle***, and governance and policy should promote the sustainable use of water resources.

- ***Reinvigorate the Sustainable Development Plans*** that have been operative since the 1990s, which constitute an invaluable socioeconomic, policy and knowledge asset that should be put at the forefront of the policy agenda. Building on these plans, foster the sustainable use biodiversity and water resources, through the harmonisation of urban, agricultural and industrial uses with ecological and environmental ones.

2. **Enable, through a transparent process, a mandate-implementation panel that is widely acknowledged as impartial, trustworthy and independent.** The following issues deserve careful consideration:

- ***Base the composition of the panel on multiple knowledge streams*** combining local/traditional, management and scientific knowledge. Include knowledge-transfer specialists able to foster the judicious integration of inter-disciplinary information (including but not being limited to: scientific, engineering, economic, policy and legal analyses).
- ***Strive for organisational and institutional efficiency***. Rely on existing arrangements, such as the Participation Council and the inter-agency monitoring team of the Doñana Nature Reserve, as well as on the inter-organisational links and stakeholder relationships created by the Doñana 2005 and the Guadiamar's Green Corridor projects.

3. **Foster public and stakeholder participation in the process**. The following issues deserve careful consideration:

- Effective governance and policy change will best work upon the ***participatory elaboration of a strong case about institutional, socioeconomic, water use and wetland conservation issues and problems in Doñana***, demonstrated and accepted collaboratively by local stakeholders.
- ***Devote the necessary efforts to the pro-active engagement of stakeholders and the general public, and the collaboration among local communities, decision makers and government***, which will be key to legitimise the process and will help

improving policies and actions based on shared learning about their outcomes and the risks or uncertainties involved.

- ***Precede the process by an extensive phase of information sharing and trust building***, necessary to overcome Doñana's history of conflict over values associated with wetland and water use, as well as inter-agency lack of coordination and mistrust.
- ***Make a strategic effort to include external stakeholders with expertise in issues and problems whose influence extends beyond regional boundaries*** (e.g., ecological processes, worldwide changes in rice markets).
- ***Design and manage the participation process with the aim of building consensus on the most difficult choices*** regarding water resources use and marshland/wetland conservation, which may be aided by a process of (truly) shared evaluation of the existing synergies and trade-offs between both activities[46].

4. **Enable adaptive management and policy making for water use and wetland conservation, with a focus on improving the science-management-policy interface** – particularly in situations of high risk and operational uncertainty, characteristic of the Doñana case. The following issues deserve careful consideration:

- ***Treat policies as experiments*** – i.e., conceive, promote and deal with policies as a continual and cyclic process proceeding through subsequent iterations and replications locally, in order to speed up learning and the generation of solutions in response to knowledge gaps, socioeconomic and ecological change and the potential emergence of conflicting goals.
- ***Seek the continuous deliberation on scientific-technical findings and updates***, in order to inform collectively-defined goals and learning objectives, prioritise monitoring strategies, and update policies, strategies and management actions.

[46] For example, a key question that arose during the action-research program in Doñana was "what Doñana do we want?" ("¿Qué Doñana queremos?"), in the context of the potential reopening of the protected marshland/wetland ecosystems to "free" fluvial and tidal influence through the restoration actions of the Doñana 2005 project. These type of questions are potentially conflictive, since the different alternatives available mean different futures for water use and for the protected aquatic ecosystems, and because those futures represent different interest and values.

- ***Develop strategies that balance scientific rigour, management relevance and the opportunity to inform policies and management actions***, while accounting for socioeconomic and biophysical interactions and feedbacks.
- ***Improve existing instruments for information exchange and goal definition among the main decision-making agencies***, including (at least) the Doñana Nature Reserve, the Doñana Biological Station and the Guadalquivir River Authority. Foster the science-management dialogue through the creation of a collaborative platform/forum, supported by protocols, standards, joint committees, virtual workspaces and corporate databases for mutual support and joint decision making.
- ***Maximise the use of existing organisational and institutional arrangements***, in order to avoid additional bureaucracy and increase efficiency.
- ***Rely on information exchange processes to collaboratively build a collective understanding of the functioning and desirable future of the Doñana water socio-ecosystem***, based on different sources of knowledge (e.g., scientific, technical, entrepreneurial, traditional) and sectoral perspectives (e.g., water resources management, wetland conservation, rice agriculture). A comprehensive understanding of system structure and functions will facilitate the synergic action of the multiple agencies involved in decision making and action.
- ***Assess the risk and uncertainty associated to alternative policies and management actions*** over services, functions and benefits that water resources and wetland ecosystems provide to society and nature. A better knowledge of these risks and uncertainties will guide and facilitate the definition of shared goals, and the planning and prioritisation of strategies helping to buffer risk and decrease uncertainties, at adequate spatiotemporal scales.
- ***Structure existing monitoring programs***, based on established goals and functioning models, and seeking to optimise coordination among agencies. Identify hypotheses about the potential effect and risk of alternative policies or management actions, and establish monitoring strategies based on them, through participatory modelling.
- ***Plan for cost-effective (adaptive) management*** in order to allocate public resources wisely, by prioritising strategies aimed at reducing uncertainties that pose high risks or socioeconomic costs, or that affect highly vulnerable areas or

sectors. The establishment of learning objectives would help in prioritising adaptive management strategies and in evaluating their cost-effectiveness.

- ***Support the introduction of learning, novelty and innovation into the science-management-policy interface***, by the transfer of knowledge generated in well-defined extant pilot projects and programs (e.g., Caracoles Estate restoration project).
- ***Create a transparent and solid science-policy-society interface*** to keep stakeholders engaged in continuous collaboration, and to inform the broader public and society about the process of making the Doñana case and about the broader collaborative adaptive governance structure.
- ***Promote the transfer of lessons*** on opportunities, constraints, critical facts and guidelines for effective adaptive management from successful case studies elsewhere in the world.

5. **Allow for flexible and adaptable organisational and institutional arrangements** that can be adjusted in the light of new information and knowledge from adaptive management and monitoring.

- ***Develop a robust participatory process***, which will be instrumental for enhancing flexibility and adaptability. Shared and collaborative learning can help to progress towards innovative organisational and institutional designs, with greater flexibility to address existing and emergent problems and issues.
- ***Adjust organisational and institutional arrangements based on demonstration of successful projects and pilot initiatives*** that have shown to work towards the desired goals, with the aim of at up-scaling them while keeping in balance with efficiency enhancements and net welfare gains.

6. **Define, within the current Management Plan of the Guadalquivir River Basin, a specific sub-basin plan for the Doñana water socio-ecosystem including its marshland/wetland ecosystems and main tributaries (e.g., Guadiamar River).**

- ***The 'Doñana sub-basin' would resolve the contradiction inherent to the declaration of most river branches flowing into or surrounding Doñana as***

'highly modified watercourses' following the provisions of the European Union's Water Framework Directive – a status that frees the River Authority from the obligation of achieving a 'good ecological status', which seems in open contradiction with the requirements of the Habitat Directive for Doñana's wetlands.

- ***The 'Doñana sub-basin' would require and facilitate a coordinated governance among local, regional, national and supranational (EU) authorities, policies and legislation***, as well as the geographic jurisdictions that affect the Guadalquivir basin. It could also help harmonising the needs of the rice farming and wetland conservation sectors – since both share a dependence on "high-quality" (fresh)water from the river basin, for which they compete with other sector (e.g., navigation, urban development).

7. **Incorporate independent and transparent instruments for institutional surveillance and monitoring** within the governance structure, at the collective-action level and cost-effective, aimed at[47]:

- ***Supporting greater cost efficiency and financial performance, and increasing awareness among stakeholders,*** ensuring that short-term political considerations are not steering policy, decision-making or management actions having long-term infrastructural or economic consequences. For this purpose, it should have clear guidelines to establish responsibilities for both implementation and maintenance costs, as well as evaluative instruments and criteria to evaluate their efficiency.
- ***Facilitating stakeholder and local-community access to new information and knowledge on sensitive issues*** such as risks, uncertainties and vulnerabilities elicited along the adaptive policy and management processes, as well as on budget

[47] These mechanisms would help in early assessments of potential risks and problems related to path dependence issues such as: (1) power imbalances or truly random events that can significantly and undesirably divert agreed policy trajectories from established goals; (2) badly planned investments with high opportunity costs of continuing to use inefficient techniques or technologies – at risk of becoming locked-in, and posing high sunk or too high transaction costs, thus making outcomes irreversible. The role of newly generated information and knowledge would be crucial for the effectiveness of this mechanism, for it plays a crucial role in the assessment of risk and uncertainty. The operation of governance within a participatory and adaptive framework could facilitate the flexible and strategic input of newly generated information and knowledge into policy and decision making. Other potential measures to decrease the risk of undesired social-ecological trajectories could be the diversification and decentralisation of sources of design for infrastructure that are appropriate in scale, financial instruments and sources of knowledge (which can add value by diversifying perspectives).

allocations. Greater transparency on this information can be expected to improve accountability and increase public awareness about the main problems faced by the Doñana socio-ecosystem.

- ***Identifying institutional loopholes that may lead to corruption and the associated mismanagement of public resources***. For this purpose, the instrument proposed should have an auditor role, and be informative and cautionary – though it should not be endowed with legislative, sanctioning or intervention powers, to avoid compromising the proactive process of trust building and reinforcement among actors.

8. Foster and welcome novel discourses for effective water governance, which frame water resources management and wetland conservation issues in a participatory, learning-by-doing paradigm and departs from historical, fixed-optimum panaceas.

- ***Promote novel discourses and ideas*** that capture the complex, dynamic and uncertain nature of socioeconomic and ecological processes, and lay out the shortcomings that characterise traditional approaches to management and conservation (e.g., scientific management, command-and-control, market-based approaches). Such novel discourses should embrace alternative social and environmental values; integrate socio-cultural, institutional, economic and ecological systems in a wider process of social learning and collective action; complement traditional approaches by addressing key factors influencing social welfare at a wider social and political level; and enrich the institutional designs that govern lower institutional and organisational levels.
- ***Promote new narratives based on the realisation of the multiple and invaluable roles plaid by a sustainable supply of freshwater across all different sectors*** (e.g., through the generation of socioeconomic and ecosystem services), thus moving away from the classical conception of water use and management as a purely technical-engineering process (even when it is used for nature conservation).

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List of appendices

Appendix 1. TRANSAM Project: Question guide

A. Introduction

We are working in a project funded by the International Council for Canadian Studies (Government of Canada), to investigate into the cause of the limited transfer of adaptive management to the European Union. We are interested in learning about (1) what were the opportunities and constraints to test or implement adaptive management in Canada, specially in British Columbia; and (2) the recent institutional developments that have allowed for the implementation of adaptive management in the Clayoquot Sound Biosphere Reserve for sustainable forest management. Within the project, we will also carry out an action-research program (co-funded by the Doñana 2005 Project, Government of Spain) to promote and facilitate the implementation of adaptive management strategies for water resources management and wetland conservation in the Doñana Nature Reserve (DNR) (this part followed by a brief explanation about the DNR's ecosystems and geomorphology with the aid of maps and drawings). Nowadays, the DNR is under hydraulic-ecological restoration (background if requested). Within the project, some key actors recognised the project as a window of opportunity and managed to start a pilot project based upon an adaptive management approach. Unfortunately, due to subsequent events and owing to the novelty of this approach for the local managers, officials and academics, the project is blocked due to several constraints at the socio-political level.

B. Questions

1. What is the function of your organization?
   Primary themes (non-consecutive, alternative):
   - Function in the field of natural resources.
   - Function in the field of nature conservation.
   - Function in the field of adaptive management.
   - Function within the Clayoquot Sound Biosphere Reserve.

2. What type of organisation is it (scientific-technical, private, government, First Nations, NGO)?

3. What is your role within the organization?

4. What is your general perspective about natural resources management in Canada?
   Primary themes (subsequent and consecutive):
   - Natural resources management in British Columbia.
   - Natural resources management in Clayoquot Sound.

5. What is your general perspective about nature conservation in Canada?
   Primary themes (subsequent and consecutive):
   - Nature conservation in British Columbia.
   - Nature conservation in Clayoquot Sound.

Let´s talk about the following project (or initiative): [Name of project or initiative].

6. What problem was being assessed?

7. Why are practitioners using AM? How was AM implemented? How well is AM working?
   Primary themes (non-consecutive, alternative):
   - Rationale for adopting adaptive management.
   - Conceptualisation of adaptive management.
   - Spatial scale of application.
   - Steps of the adaptive management approach being implemented.
   - Extent of stakeholder involvement.
   - Extent of feedback from monitoring to changes in management practices.
   - Types of indicators used.
   - Ecological outcomes of the project.
   - Social outcomes of the project.
   - Main lessons learned.

We define institutions as "the rules of the game that humans use to organise all forms of organized, established, social procedures (formal and informal rules, organizations, scientific paradigms and technologies)" (Brief explanation of concepts if requested).

8. What were the main opportunities and barriers that the project encountered in the institutional realm?
   Primary themes (non-consecutive, alternative):
   - Formal (e.g. legislation, policies) and informal rules (e.g. innovation networks, lobbies).
   - Organizations (e.g. research organizations –universities, institutes–, management agencies).
   - Scientific paradigms (e.g. command-and-control approaches, ecosystem-based management).
   - Technologies (e.g. information technologies).

Appendix 2. TRANSAM project: Consent letter and form

MEDITERRANEAN INSTITUTE FOR ADVANCED STUDIES (IMEDEA)
LABORATORY OF SPATIAL ECOLOGY

Pablo F. Méndez
Researcher in training
Laboratory of Spatial Ecology (IMEDEA)

[Date]

[Name of participant]
[Position]

Dear [title] [surname of participant]:

We are writing to invite you to participate in a retrospective research study. The purpose of the study is to undertake a comparative analysis of the institutional opportunities and constraints for the implementation of adaptive management (AM) in Canada (British Columbia) and the European Union (Spain), in the fields of natural resources management and nature conservation.

We are inviting you to be in this study because we work under the hypothesis that the actors and experts identified and interviewed during the preliminary stages of our research have a sound understanding of the existing institutional opportunities and constraints for the implementation of AM in the mentioned fields. This includes, either totally or partially, the following issues:

- The evolution, during the last century, of the Canadian, federal-provincial institutional framework for natural resources management and nature conservation.
- The recent institutional developments in natural resources management and nature conservation in the Clayoquot Sound.
- Rationale for adopting AM in identified projects.
- Conceptualisation of AM.
- Spatial scale of application.
- Steps of the AM approach being implemented.
- Extent of stakeholder involvement.
- Extent of feedback from monitoring to changes in management practices.
- Types of indicators used.
- Ecological outcomes of the project.
- Social outcomes of the project.
- Main lessons learned.

We obtained your name and address either during prior interviews with other participants or directly from your corporate web.

If you agree to participate, we would like to use direct quotes from you in published technical publications and articles. We will keep the non-published information you provided confidential, however international and Spanish regulatory agencies may inspect and copy records pertaining to this research. We are using ID code numbers on every transcripted interview. If you do not agree to participate in our study we will destroy the link between the code number and the person's name after the study is over, and if we publish the results of this study we will do so in such a way that you cannot be identified.

There are no known risks from being in this study. Its related publications will be valuable to all the participants and other experts from the scientific community. This would serve the additional goal of providing with several guidelines and articulates on how AM practitioners can best proceed to further develop new management strategies and more specific decision making structured tools, therefore benefiting in the future from what we learn as a result of this study.

Taking part in this research study is completely voluntary. If you decide not to be in this study, or if you stop participating at any time, you won't be penalised or lose any benefits for which you otherwise qualify. If you have any questions about the research study itself, please contact Pablo F. Méndez (please find contact information below). Please note that returning the attached consent form will indicate your willingness and consent to participate in the study.

Thank you very much for your time and consideration.

Sincerely,

Signed: Pablo F. Méndez

[Contact information]

CONSENT FORM

Project title: Transfer of adaptive strategies for natural resources and ecosystems management in Canada – Opportunities and constraints for implementation in Europe (TRANSAM Project)

	Please initial box	
1. I confirm that I have read and understand the information included in the technical publication of the TRANSAM Project and I have had the opportunity to ask questions	☐	
2. I understood that my participation was voluntary and that I am free to withdraw at any time, without giving reason	☐	
3. I agreed to take part in the studies carried out in the TRANSAM project	☐	
	Please tick box	
Note for researchers: Include the following statements, if appropriate, *or delete from your consent form (totally or partially)*:	Yes	No
4. I agreed to the interview being audio recorded	☐	☐
5. I agreed to the workshop being video recorded	☐	☐
6. I agree to the use of anonymised and direct quotes in future publications	☐	☐
7. I agree that my qualitative data gathered in this study may be stored (after it has been anonymised) in a specialist data centre and may be used for future research	☐	☐

Name of participant	*Date*	*Signature*

Pablo F. Méndez		
Name of researcher	*Date*	*Signature*

Appendix 3. Action-research program: Question guides

A. Introduction

We are carrying out an action-research program funded by the Doñana 2005 project, to promote the use of adaptive management in water management and wetland conservation in the Doñana Nature Reserve in situations of high uncertainty on the effects of the decisions made and actions undertaken (e.g., hydro-ecological restorations). The program is conceived as a strategy to promote and facilitate a process of change towards adaptive management of water resources management and wetland conservation in the Doñana Nature Reserve, through the step-wise, bottom-up introduction of innovations from the operational levels. This strategy is being informed by a research funded by the International Council for Canadian Studies (Government of Canada), aimed at investigating into the cause of the limited transfer of adaptive management to the European Union. One of the specific objectives of that research was to identify the institutional opportunities and constraints for a process of change towards adaptive management in the Doñana Nature Reserve, by learning from a number of cases from British Columbia (Canada) applying adaptive management in natural resources and ecosystems management in general.

B. Questions

1. What is the function of your organization?
   Primary themes (non-consecutive, alternative):
   - Function in the field of water resources in the Guadalquivir Estuary.
   - Function in the field of wetland conservation in the Guadalquivir Estuary.
   - More specific function within the Doñana Nature Reserve.

2. What type of organisation is it (public, private, non-profit)?

3. Which are your duties within your organization?

4. What is your general perspective about water resources management in Doñana and the Guadalquivir Estuary?
   Primary themes (subsequent and consecutive):
   - General perspective and opinion.
   - EU's policies and legislation.
   - National and regional policies and legislation.
   - Research and management.
   - Operational management.

5. What is your general perspective about wetland conservation in Doñana?
   Primary themes (subsequent and consecutive):
   - General perspective and opinion.
   - EU's policies and legislation.
   - National and regional policies and legislation.
   - Research and management.

- Operational management.

Let´s talk about the "Doñana 2005" Eco-Hydraulic Restoration Project.

6. What problem was being assessed?

7. What is your general perspective about the management of the Doñana 2005 Project?
   Primary themes (subsequent and consecutive):
   - General perspective and opinion.
   - Research and management.
   - Operational management.

8. More specifically, what is your general perspective of the restoration action carried out at the Caracoles estate which, as you might know, was designed under adaptive management tenets?
   Primary themes (subsequent and consecutive):
   - General perspective and opinion.
   - Research and management.
   - Operational management.

We define institutions as "the prescriptions that humans use to organise all forms of organized, established, social procedures (formal and informal rules, organizations, epistemological domains and technologies)" (Brief explanation of concepts if requested).

9. Which were the main opportunities and barriers that such action encountered in the institutional realm?
   Primary themes (non-consecutive, alternative):
   - Formal (e.g., legislation, policies) and informal rules (e.g. innovation networks, lobbies).
   - Organizations (e.g., research organizations –universities, institutes–, management agencies).
   - Scientific-technical perspectives (as a surrogate of epistemological domains; e.g., command-and-control approaches, ecosystem-based and adaptive management).
   - Technologies (e.g., information technologies).

Appendix 4. Output models from the Group Model Building session of the research-management workshop

Figure A4.1. Water-management model.

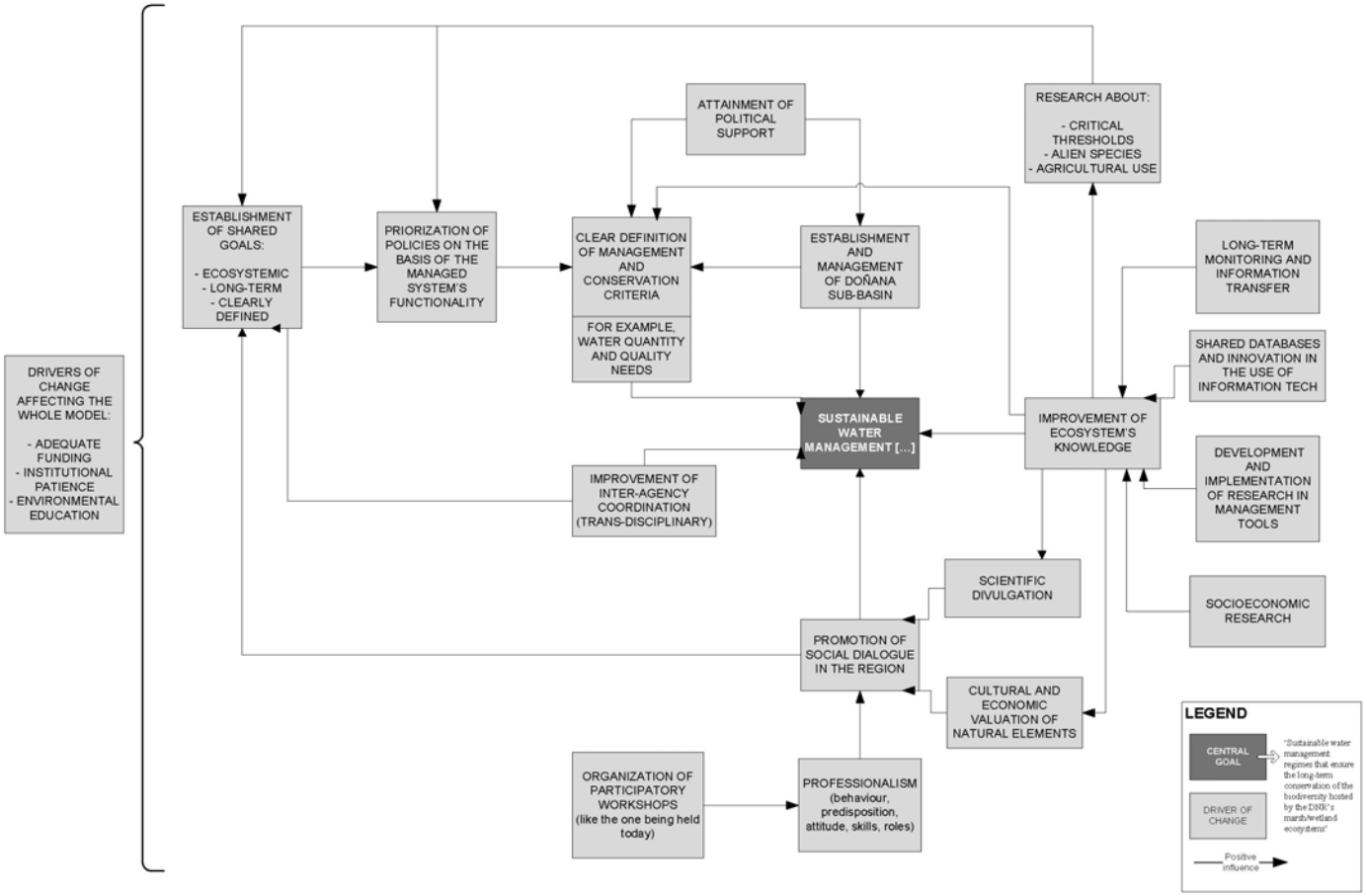
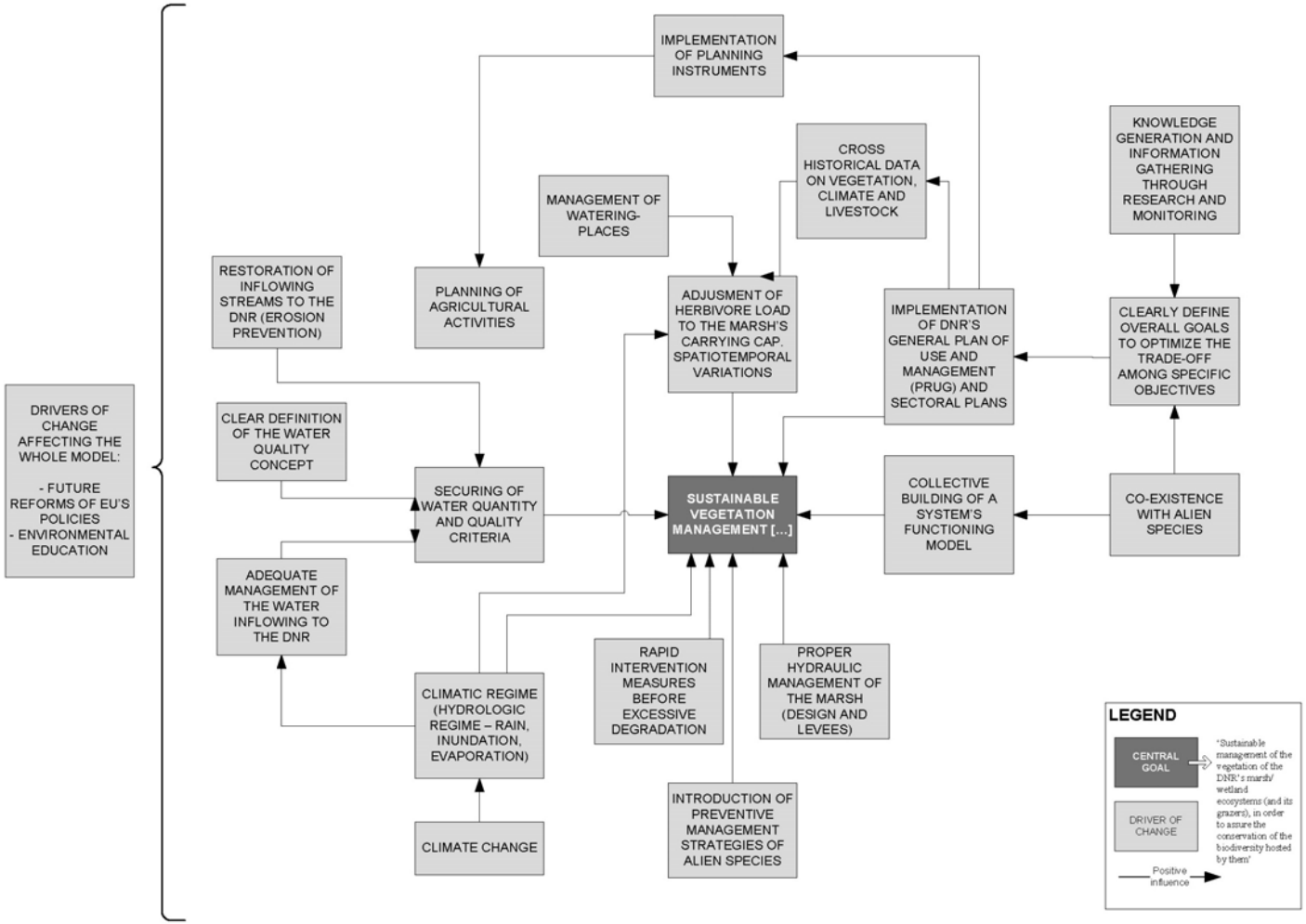
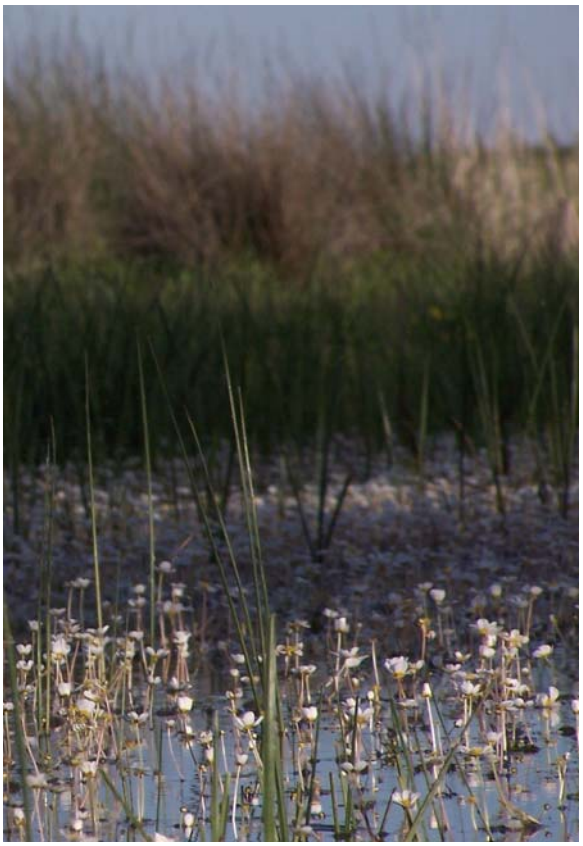


Figure A4.2. Vegetation-management model.



Appendix 5. Policy document prepared for the participants of the research-management workshop



Un informe sobre el taller participativo de Matalascañas, en el que se debatieron las estrategias para mejorar la transferencia de la información científico-técnica y la toma de decisiones en la gestión de las marismas del Espacio Natural Doñana.

Integración de la Gestión y la Investigación en las Marismas de Doñana:
Estrategias Innovadoras y Gestión Adaptativa

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Instituto de Investigación de Sistemas Ambientales (USF), Osnabrück, Alemania

Government of Canada / Gouvernement du Canada

ICCS

IMEDEA

SWAN

IRES

USF

Participan

Espacio Natural Doñana

Confederación Hidrográfica del Guadalquivir

Estación Biológica de Doñana

Proyecto Doñana 2005

Recomendaciones clave de los participantes

1

Desarrollar un proceso para definir, de forma transparente y compartida, los objetivos de gestión y el modelo de funcionamiento de la marisma del END.

El proceso debería centrarse, en primer lugar, en los actores clave de las diferentes agencias de gestión, y ampliarse en una segunda fase a los diferentes actores del entorno.

2

Estructurar el programa de seguimiento a partir de los objetivos de gestión y el modelo de funcionamiento de la marisma del END, optimizando la coordinación institucional.

El perfeccionamiento del plan de seguimiento incluiría, entre otros factores:

- *Continuidad: asegurar su diseño y mantenimiento a largo plazo*
- *Acceso: facilitar la distribución de sus resultados a tiempo real (o en plazos razonablemente cortos)*
- *Utilidad: facilitar su uso por las agencias de gestión.*

3

Incorporar la investigación y la participación social (entorno del parque) a los procesos de elaboración de políticas y planes de gestión, con objeto de:

→ Mejorar los procesos de toma de decisiones.

→ Entender e involucrar al entorno social.

4

Definir, en el nuevo Plan Hidrológico de la Cuenca del Guadalquivir, una subcuenca específica para el Espacio Natural Doñana.

El objeto sería elevar el nivel de exigencia, tanto en los objetivos de gestión como en densidad y calidad de la red de seguimiento, para las cuencas que vierten directamente a la marisma del END y los tramos del Guadalquivir con una influencia directa sobre ésta. La declaración de una subcuenca con un plan de gestión y seguimiento diferenciado ayudaría, además, a resolver la contradicción que implica la declaración de varios tramos de río como "muy modificados" en la inmediata vecindad de un humedal de especial importancia nacional e internacional.

5

Continuar y potenciar la dinámica de colaboración creada por el accidente de Aznalcóllar.

Los participantes la perciben como un bien social que surgió después del accidente, que habría que potenciar política y económicamente. El ambiente de cooperación se plasmó en varios cambios en el funcionamiento institucional (Consejo de Participación, Comisión Científica Mixta) y creó una mayor cultura de cooperación y objetivos compartidos. Para aprovecharlo al máximo, sería deseable que hubiera una sanción oficial (reconocimiento) que le diera un mayor perfil político y abriera nuevas vías de financiación.

6

Mejorar los mecanismos para el intercambio de información, uso de resultados y definición de objetivos comunes entre el END y la EBD (p.ej. comisión/es, espacios virtuales, etc.).

Las exigencias del funcionamiento diario de las diferentes organizaciones (END, EBD, CHG) dificultan el intercambio fluido de información, conocimiento experto y opiniones. Sería deseable que un grupo de trabajo conjunto estudiara la creación de mecanismos específicos de apoyo mutuo. Las posibilidades incluyen la creación de comisiones conjuntas, grupos de trabajo, espacios virtuales (foros, bases de datos corporativas), etc.

7

Introducir las nuevas ideas e iniciativas de gestión de forma sencilla y progresiva, construyendo a partir de proyectos bien definidos y difundiendo las lecciones aportadas por éstos.

Antecedentes

El taller de Matalascañas, enmarcado en el proyecto TRANSAM (“*Transference of Adaptive Management*”), se centró en la presentación, análisis y debate de las políticas y planes de gestión, investigación y seguimiento en la marisma del Espacio Natural Doñana, y sus interrelaciones con la gestión del agua en el Estuario del Guadalquivir. Durante el taller, se hizo un esfuerzo específico por identificar las incertidumbres y barreras institucionales que condicionan la mejora de dichas políticas y planes. El análisis posterior de la información obtenida en el taller permitirá una evaluación más profunda de los valores, creencias, intereses, responsabilidades y percepciones de las partes interesadas, y su influencia sobre la toma de decisiones y la transferencia de conocimiento.

El taller nace en el marco de un estudio comparativo de casos entre el Espacio Natural Doñana y la Reserva de la Biosfera de Clayoquot Sound (Columbia Británica, Canadá). Fue diseñado en paralelo a un taller realizado en la Universidad de la Columbia Británica (Vancouver). Los objetivos de este último fueron aprender de la experiencia canadiense en Gestión Adaptativa, identificando las oportunidades y barreras institucionales que han condicionado su implementación. Además, recopilamos información acerca del papel de la investigación y los procesos de consulta pública en la elaboración de políticas (provinciales y federales) de uso de los recursos naturales y protección de ecosistemas.

Presentaciones temáticas

· La gestión en el END

Juan Carlos Rubio · *Director*
Carlos Urdiales · *Técnico de conservación*

Espacio Natural Doñana

Mensaje – *El END es un territorio de una gran complejidad ecológica y social, sometido históricamente a un proceso de aprendizaje continuo fundamentado en una gestión complicada y en grandes cambios sociales. Sus sociedades hay que comprenderlas a partir de su estructura socioeconómica y sus expectativas de futuro. La planificación futura de éste territorio tendrá que estar basada en: la armonización de las políticas supranacionales, nacionales y regionales; la diversidad de inversiones económicas; y la participación social y sectorial. Para enfrentarse con éxito a la planificación de un territorio tan complejo, habrá que alcanzar el máximo consenso posible entre la gestión y la investigación.*

Presentación y debate – La gestión de la marisma del END se organiza en torno a tres objetivos prioritarios:

- Recuperación de la naturalidad de la marisma.
- Potenciación de la biodiversidad.
- Uso sostenible de los recursos naturales.

Es necesario un conocimiento adecuado del funcionamiento de la marisma para analizar los problemas y las soluciones que se han implementado recientemente. Los grandes problemas a los que se enfrenta dicha gestión en la actualidad son: (1) la alta presión de herbivoría en la marisma; (2) las molestias (naturales y antrópicas) que sufren las colonias reproductoras de aves acuáticas; y (3) las grandes modificaciones hidráulicas de la marisma. El escenario futuro de funcionamiento y gestión más inminente será el generado por el proyecto de restauración Doñana 2005. El sistema de compuertas remanente seguirá constituyendo la única posibilidad de manejo activo de la marisma, mediante el control del flujo de descarga hacia el estuario.

El conocimiento del sistema hidrológico generado desde los años 90, junto al seguimiento continuo, permiten referir los criterios de manejo de las compuertas a la geometría y topografía de la marisma natural, en función de las condiciones ecológicas e hidrológicas, disminuyendo la arbitrariedad, intuición e incertidumbre en el manejo de la misma. Con respecto a la gestión de las cuencas vertientes, las autoridades competentes están siguiendo varias líneas de actuación para resolver los principales problemas: aguas residuales e industriales, erosión de suelos agrícolas, contaminantes agrícolas y vertederos de residuos sólidos.

La contribución de las aguas subterráneas al ciclo de inundación anual de la marisma natural es poco relevante desde el punto de vista cuantitativo, pero es muy importante desde el punto de vista cualitativo.

Para las zonas de marisma transformada dentro de la marisma del END, que están sometidas a inundación artificial, debería establecerse un plan de manejo que integre los criterios de producción y de conservación.

Las posibles soluciones al problema del sobrepastoreo de la marisma, un ecosistema con una capacidad de carga variable e irregular en el tiempo, podrían incluir: la implementación de las zonas de reserva establecidas en el PRUG; la reducción de la carga ganadera hasta límites fijos, considerados sostenibles y compatibles con la conservación de la cubierta vegetal; el establecimiento de las cargas admisibles con la conservación de la cubierta en cada uno de los escenarios de inundación y estado de la vegetación anuales; y la adecuación del concepto de "explotación ganadera" a las necesidades de conservación y a las realidades jurídicas del END (p.ej. posibilidad de alternancia estacional o nomadeo controlado de los rebaños dentro del espacio, en función de la carga tolerable en cada momento y lugar). Es una solución que tendrá que ser promovida con el colectivo de los ganaderos y con las municipalidades del entorno.

Recientemente se ha descubierto que la principal causa de mortandades en la marisma de Doñana es la proliferación masiva de cepas tóxicas de cianobacterias. La principal solución, actualmente, es evacuar parte de las aguas hacia el estuario para acelerar la desecación. En los últimos años, se ha establecido un sistema de alerta temprana.

Las medidas de protección de las colonias reproductoras de aves acuáticas son, principalmente: la instalación de cercados que evitan perturbaciones y el acceso de ganado y jabalíes; y la regulación de tránsitos y actividades en la marisma (proyectos de investigación y actividades ganaderas, como la Saca de las Yeguas).

· La investigación en el END

Xim Cerdá · *Vicedirector*

Estación Biológica de Doñana

Mensaje – *La Estación Biológica de Doñana es uno de los institutos del CSIC en que la investigación está más relacionada con la gestión. La EBD y el END no tienen una dependencia estricta. Actualmente hay una buena relación y transferencia de la información. Legalmente, los programas de investigación científica deberán elaborarse por el equipo de gestión del END, en coordinación con la Estación Biológica de Doñana y las universidades andaluzas. El responsable de coordinar la investigación en el END es también el director de la EBD.*

Presentación y debate – La EBD es el principal organismo investigador en el END. Participa además en la regulación de dicha investigación a través de la tramitación de permisos, el seguimiento de la investigación, la elaboración de informes anuales y la gestión de bases de datos. En el END pueden investigar científicos de cualquier centro, siempre que tengan proyectos financiados y tramiten los correspondientes permisos. Además, la EBD pone a su disposición diversas facilidades para llevar a cabo sus trabajos.

El análisis de las publicaciones científicas en el período 1854-2003 indica que ésta se ha concentrado en las aves, mamíferos, flora e hidrología (por orden de importancia). Aunque en la EBD se potencian, de manera informal, los proyectos relacionados con los problemas que afectan al END, tan solo existe un compromiso formal para los proyectos que desarrolla el equipo de seguimiento de los procesos naturales.

Entre 2000 y 2007, un 29% de todos los proyectos de investigación realizados dentro del END guardaron relación con la marisma. Aunque los proyectos de investigación de la EBD han logrado que haya una gran acumulación de información, no hay que olvidar que el objetivo primordial de los investigadores es la producción científica, no necesariamente acerca de Doñana y su entorno. Sin embargo, los proyectos financiados por el OAPN y los temas de investigación sobre la marisma pueden tener mucha importancia para la gestión. Por ello, el PRUG de Doñana establece una serie de líneas prioritarias en las que hay que realizar investigación, aunque actualmente son pocos los proyectos dedicados a dichas líneas. Destacan, como temas de importancia emergente, el efecto del cambio global, que generará modificaciones importantes en la marisma - como las causadas por las especies invasoras.

Políticas de investigación y mecanismos de transferencia de conocimiento para el apoyo a la gestión – No hay una política dirigida de investigación para la gestión. Aunque existen mecanismos institucionales y administrativos de financiación de proyectos aplicados (a través del OAPN y la Consejería de Medio Ambiente), la interfaz entre la gestión y la investigación es muy difusa. Para potenciarla, habría que dotar las líneas prioritarias del PRUG de instrumentos de financiación que sirvan de soporte a los proyectos. Uno de los proyectos que hay actualmente en marcha es la redacción de un plan de investigación para Doñana.

Diferencias entre la gestión y la investigación – El gestor tiene un trabajo claro de respuesta a la sociedad y necesita respuestas inmediatas a problemas concretos, mientras que el investigador busca avanzar en el conocimiento y el plazo pasa a ser secundario. Esto es, ambos colectivos difieren en las escalas temporales y prioridades a la hora de dar respuesta a las demandas de la sociedad. Desde el colectivo investigador se critica que esta diferencia refleja también una cierta falta de previsión a largo plazo de las iniciativas de gestión: en muchos casos, cuando el problema es inminente, notorio, visible socialmente, se buscan precipitadamente soluciones a corto plazo. Desde el colectivo de gestores se enfatiza que el investigador debe facilitar las alternativas que tiene el responsable de la gestión, pero es éste quien debe asumir la responsabilidad de la elección. Las alternativas vienen de abajo, de la investigación e innovación, pero, para que se produzcan los cambios, debe de haber un claro mandato desde arriba.

Gestión Adaptativa – La disociación entre los plazos y los intereses de la investigación y la gestión es una de las cuestiones clave que trata de resolver la GA. El enfoque consiste en actuar de forma que se pueda aprender de cualquier operación u acción, evitando la "parálisis por análisis". Se trata de utilizar los métodos de experimentación y observación que han desarrollado los investigadores, para diseñar la gestión de forma que se facilite el aprendizaje continuado. Es una metodología que trata de aprovechar los dos sectores aprovechando las fortalezas de ambos.

Transferencia de información – Aunque se han hecho muchos esfuerzos para mejorar la transferencia de información, ésta sigue sin estar disponible en el sitio y momento adecuados para la toma de decisiones. Hay una necesidad de mejorar los mecanismos de transferencia de conocimiento y resultados entre investigadores y gestores.

· Gestión del agua en la Cuenca del Guadalquivir

Agustín Argüelles · *Jefe de la Oficina de Planificación Hidrológica*

Confederación Hidrográfica del Guadalquivir

Mensaje – *La confederación se encuentra inmersa en la elaboración y los procesos de consulta pública de los Planes Hidrológicos de Cuenca (PHC) que prescribe la Directiva Marco de Aguas (DMA). Muchos de los temas importantes de la planificación de la Demarcación Hidrográfica del Río Guadalquivir, son trascendentales para la gestión del END. Los primeros pasos incluyen el conocimiento de los problemas a los que se enfrenta la gestión del río. Las marismas del END, que hasta ahora estaban catalogadas como aguas de transición y costeras, fuera de las competencias de la confederación, ahora han pasado a ser responsabilidad de diferentes administraciones reunidas en el Comité de Autoridades Competentes, que será una pieza clave de la planificación hidrológica. Ésta última es muy novedosa, difusa e inevitablemente tecnocrática. Los conceptos que incluye son de interpretación difícil, incluyendo el principal objetivo a cumplir, la mejora del estado ecológico de las aguas de la cuenca.*

Presentación y debate – El modelo de Planificación Hidrológica propuesto por la DMA es muy novedoso. La clasificación de las aguas de transición del Guadalquivir se basa en el régimen mareal y la salinidad. Las aguas de transición de la Demarcación del Guadalquivir se han dividido en 11 masas de agua, que se corresponden con el Tronco del Río Guadalquivir, los brazos existentes al Oeste (Brazo de la Torre) y Brazo del Este, la Dársena de Alfonso XIII y el tramo final encauzado del río Guadaira. La mayoría de estas masas han sufrido importantes alteraciones hidromorfológicas que obligan su consideración como masas de agua muy modificadas. En el Guadaira, solo el tramo final justifica su encuadre en esta clase de masas. Tanto el Brazo del Este como el Brazo de la Torre carecen de funcionalidad clara como masas de agua de transición. El Brazo del Este realmente funciona, y es gestionado por la CMA, como una zona húmeda (Ramsar): tiene la posibilidad de conectarse con las mareas a través de unas compuertas, y recibe aportes de ríos y retornos de zonas regables, con los consiguientes riesgos de eutrofización.

Los datos analíticos utilizados para la determinación del estado de las masas de agua de transición pertenecen a la red de seguimiento de la CMA, utilizándose el periodo 2003 a 2007. Además, se han empleado datos de algunas estaciones de la red ICA de la CHG (también para el mismo periodo).

Las principales fuentes de contaminación que afectan al estuario del Guadalquivir son las procedentes de los vertidos de aguas residuales de las poblaciones de su entorno (entre las que se encuentran las EDAR de Sevilla y las del Aljarafe), y los aportes de sus dos principales afluentes en la zona: el río Guadaira, afectado por vertidos urbanos e industriales, y el Guadiamar, que recibe efluentes urbanos, agrícolas y mineros (procedentes de la ya extinta actividad minera de Aznalcóllar).

La situación del estuario hace que en él se concentren todos los problemas que afectan a la cuenca. Principalmente: (1) la contaminación de las aguas, de origen puntual y difuso; (2) el elevado consumo de aguas, que impide el suficiente aporte de agua dulce; y (3) la elevada erosión, relacionada con la pérdida de cubierta forestal.

Además, las alteraciones hidromorfológicas, consecuencia del acondicionamiento del cauce para la navegación fluvial, causan su tipificación como masas de agua muy modificadas, cuyo grado de alteración no es viable modificar - por lo que los programas de medidas a establecer en el Plan de la Demarcación tan solo estarán encaminadas a alcanzar el buen potencial ecológico, en lugar del buen estado ecológico.

La declaración de “muy modificados” para varios tramos adyacentes o vertientes a las marismas del END es contradictoria con el elevado estatus de conservación y protección de este humedal. La solución podría pasar por la declaración de una subcuenca específica para los tramos que influyan directamente en este humedal. Esta solución contribuiría a resolver además la escasez de estaciones de seguimiento en dicho entorno (que, por su mayor exigencia de estatus ecológico, exigiría un seguimiento más preciso y exhaustivo).

· Coordinación de los proyectos de restauración

Benigno Bayán · *Ingeniero Jefe de la Zona Sevilla*

Confederación Hidrográfica del Guadalquivir

Mensaje – *Los proyectos de restauración ecológica "Corredor Verde del Guadiamar" y "Doñana 2005" han demostrado las ventajas de incorporar el asesoramiento de los científicos acerca del contenido (objetivos, diseño, implementación) de cualquier proyecto de restauración. Esta experiencia debería sentar precedente: funcionarios, técnicos y científicos deberían ir obligadamente de la mano. El proyecto de restauración de la Finca Caracoles permitirá, gracias a un diseño elaborado conjuntamente por ingenieros, técnicos y científicos, aprender, adquirir conocimiento del funcionamiento ecológico de la marisma y aplicar dicho conocimiento en otros casos de restauración. Fue un caso claro de Gestión Adaptativa - porque si en Doñana alguien pregunta ¿agua para qué?, deberíamos ser capaces de contestar: ese agua está para que los procesos biológicos, los procesos ecológicos, se beneficien.*

Presentación y debate – Tras el accidente minero de Aznalcóllar, tanto la Junta de Andalucía como el Gobierno Central no quisieron limitarse a limpiar el área afectada. Dieron un paso más allá, y crearon los proyectos de restauración Corredor Verde del Guadiamar y Doñana 2005. Estos dos proyectos se solapan en el territorio y en las competencias de las administraciones – por lo que han exigido la coordinación entre las dos administraciones, para ponerse de acuerdo en su contenido y desarrollo. Para ello, se centralizó la gestión en un coordinador único, respaldado por un Grupo de Apoyo, en el que había funcionarios de la Junta de Andalucía y de la CHG.

También quedó claro, tras un proceso que incluyó varias reuniones internacionales, que el objetivo central de estos proyectos, la restauración hidroecológica de Doñana, depende de numerosos procesos fisico-químicos y biológicos. Por su complejidad, requería contar con el apoyo y participación de los científicos. Para ello, se acordó crear una Comisión Científica, que no sólo ha asesorado sobre el contenido de los proyectos, sino que también ha realizado un seguimiento y evaluación de las obras conforme a los objetivos establecidos. Es decir, se ha hecho investigación aplicada a Doñana y, en especial, a la restauración de sus ecosistemas.

La experiencia de la intervención de científicos en la elaboración de proyectos es fundamental y debería sentar precedente. Aunque no es necesaria en todos los casos, lo es en proyectos de gran envergadura en los que estén implicados procesos biológicos complejos. También es importante destacar que se ha hecho lo que se ha hecho debido al accidente (esto es, como respuesta a una crisis).

Hay un caso en concreto que no ha sido únicamente "de papel y lápiz". En la Finca Caracoles, que era agrícola y se expropió para su restauración, el diseño se adaptó con objeto de obtener un mejor conocimiento del funcionamiento de la marisma. El objetivo es aprender, mediante el seguimiento de la colonización y funcionamiento una serie de lucios de diferentes tamaños, profundidades y grado de agrupación, sobre el funcionamiento ecológico de la marisma, y aplicar dicho conocimiento en otras labores. Al principio, fue una actuación que causó impacto, y tuvo que ser explicada más de una vez, hasta ser aceptada por todos como un proyecto interesante.

Las ocho obras del proyecto Doñana 2005 se han centrado en la recuperación de los cauces que históricamente llevaban agua a la marisma. A pesar de la importancia que tienen para la marisma, deben ser consideradas como un medio y no como un fin en si mismos. Si alguien pregunta ¿agua para qué?, deberíamos ser capaces de contestar para que: esa agua está para que los procesos biológicos, los procesos ecológicos, se beneficien. Un ejemplo paradigmático puede ser la Montaña del Río, construida ya en los años ochenta, que también era agua para Doñana, pero llenó la marisma como si fuera un embalse - y eso no era lo que tenía que ser. Se está dando marcha atrás ahora, porque los procesos biológicos estaban siendo perjudicados.

Imbricación del Plan Hidrológico de Cuenca con los proyectos de restauración y dragado en el Río Guadalquivir – Los objetivos del PHC son satisfacer las demandas de agua y conseguir el buen estado ecológico de todas las masas de agua. Todo lo que vaya dirigido a la consecución del buen estado tiene su encaje en los programas de medidas, que no sólo establece la CHG, sino que incluye otras medidas (p.ej. la aplicación de códigos de buenas prácticas agrarias). Con referencia a las conclusiones obtenidas por el proyecto Doñana 2005, en este encuadre de la relación con las actuaciones para la consecución buen potencial ecológico, habrá que analizarlas e incorporarlas.

Armonización del PHC con los objetivos de gestión del END – Las categorías del estado de las masas de agua se asignarán formalmente en el futuro próximo. La declaración de los tramos bajos del Guadalquivir como "muy modificados" implica la aceptación de que el buen estado ecológico no puede conseguirse, al estar prácticamente todo el cauce muy modificado por los dragados y la presencia de numerosas presas. Sin embargo, hay que conseguir que se cumpla el buen estado ecológico al máximo, ya que Doñana es un espacio protegido Ramsar, y está en el inventario de espacios protegidos que contempla el PHC. Eso hace que tenga máximo rango de protección de la calidad del agua y de exigencia en la consecución de los objetivos de buen estado ecológico. Para asegurarlo, podría ser recomendable delimitar una unidad de gestión hidrológica específica (una subcuenca) dentro del PHC.

La Gestión Adaptativa

Lecciones de la experiencia canadiense

Pablo F. Méndez

IMEDEA

La Gestión Adaptativa nació en Canadá (Columbia Británica), como una alternativa a los principios y procedimientos tradicionales para la gestión de los recursos (hídricos, pesquerías, forestales y minerales), que buscaba desarrollar un enfoque más realista y menos enfocado en el simple control de los mismos.

1 La inercia institucional dificulta los procesos de implementación de modelos innovadores para la gestión de recursos naturales y ecosistemas. Superarla requiere la confluencia de un marco estratégico, unos objetivos de gestión comunes e individuos con coraje para promover el cambio desde arriba (*directivos* y *ejecutivos*) y desde abajo (*innovadores* y *líderes internos*).

A nivel humano, el proceso de transición hacia modelos adaptativos en Canadá ha ocurrido (está ocurriendo) gracias al esfuerzo concertado de toda una generación de investigadores y gestores, influido por las ideas que emergieron en el mundo académico en los 60-70. Durante la década de los 90, han accedido a posiciones de dirección y coordinación dentro de diversas instituciones y están aplicando procesos innovadores basados en modelos flexibles y adaptativos a diferentes niveles y escalas. En la actualidad existe suficiente masa crítica de gente que entiende la idea y la está aplicando.

2 Existe un equilibrio muy delicado entre la simpleza y la complejidad en el diseño de prácticas y modelos de gestión.

No hay que rehuir la complejidad cuando esta puede determinar la respuesta del sistema a las prácticas de gestión, pero tampoco hay que incrementarla innecesariamente. La clave está en identificar el número de elementos que es necesario gestionar y monitorear para aplicar las prácticas de gestión y conocer la respuesta del sistema a dichas prácticas. Una herramienta particularmente útil es el desarrollo parsimonioso e interdisciplinar de modelos integrados de funcionamiento del ecosistema y el sistema social.

3 Para su total comprensión, responsabilidad y confianza en el uso, las prácticas y modelos de gestión deben ser elaborados interdisciplinarmente y deben ser participativos, públicos y transparentes.

Los procesos biológicos, por regla general, no tienen umbrales claros. Habitualmente, lo mejor que los investigadores del medio biofísico pueden ofrecer a los gestores, para la toma de decisiones, son interpretaciones claras y sintéticas de los resultados obtenidos usando el método científico. Y lo mejor que los investigadores sociales y los agentes de cambio (p.ej. consultores) pueden ofrecer son metodologías y diseños a largo plazo, para facilitar la participación y la inclusión de todas las partes interesadas en los procesos de cambio. El análisis y aprendizaje que incorpora la Gestión Adaptativa, sin embargo, dota a todos ellos de la capacidad y habilidades suficientes para mejorar progresivamente la calidad de las políticas y las decisiones de gestión.

4 Hay dos tipos de mecanismos de retroalimentación para informar a la gestión de las interrelaciones complejas existentes en la naturaleza: la orientación general (nivel estratégico) y la decisión informada (nivel táctico).

La orientación general posibilita la mejora continua de los marcos estratégicos establecidos y la evaluación continua de los objetivos de largo plazo. Además, facilita la institucionalización de la innovación, ya que provee de mecanismos amplios para generar confianza y alinear estrategias. La decisión informada provee a los gestores de las predicciones de diferentes alternativas de gestión, basadas en la mejor ciencia e información posibles y reduciendo las incertidumbres al mínimo.

5 La adopción de modelos innovadores de gestión (como la Gestión Adaptativa) se ve facilitada por la credibilidad derivada de proyectos piloto exitosos, que demuestren su funcionamiento.

Para reducir la inercia institucional hace falta credibilidad, esto es, que las buenas ideas que se generan en los nichos de innovación demuestren su funcionamiento. Para ello, han de promoverse las redes de innovación, promocionarse los modelos más funcionales y sencillos, y generarse cambios de actitud en los actores de los cuerpos de decisión (p.ej. entusiasmo, capacidad de aprendizaje, coraje).

Appendix 6. Systems historical narrative: resultant matrix from data collection and categorization

Cycle's phase					
WRM	**WC**	**Period**		**Key institutions**	**Main policy, economic, organizational, and scientific-technical features characterizing each period**
~-K		End of 18th century	ANCIEN REGIME	**Ancient Regime** – Local nobility entitled by royal governments or local agreements to use highly-valuable resources and to regulate the use of the less valuable by the civilian population. Non-regulated activity of hunters and collectors **1778** – *Free Trade Decree* promoting the reviving of trade at the State level. Seville and Cádiz lose their monopoly **1781** – Founding of the *Friends of the Country Society of Sanlúcar de Barrameda* (ancient province in which Doñana was included) for the promotion of economic development in the region **1794** – *Royal Order* allowing for the implementation of the first large-scale infrastructure in the Guadalquivir Estuary for enhancing navigation, the Merlina's meander cut (1795) **1798** – First *Disentitlements* allowing the expropriation of clergy's wealth (e.g., Jesuits, Charity Institutions)	Planning and management based on scattered projects, maintenance of rudimentary infrastructure and cleaning of natural, accessible water courses Property system based on multi-functional, community-based or municipal properties for agricultural activities and low water consumption regimes, immersed in larger crown and nobility properties Increasing State public deficit Reviving of the promotion of navigation in the Guadalquivir River (navigability tests, blueprints and mythology revival), after Seville's loss of trade monopoly and under the Enlightenment's Spirit of Reform Beginning of a disentitlement (nationalization-for-privatization) process of low-productivity lands for increasing their productivity First public works for enhancing navigation and river defense. Marginal agricultural development
Ω					
α		1st half of 19th century	▼ ▼ ▼	**1805** – *Promotion Plan of Sanlúcar Province*. First technical planning for the transformation of region, but almost no practical implementation **1814** – *Royal Order* allowing for the constitution of the Guadalquivir Navigation Royal Company, preceded by several navigability tests, topographical surveys and planning **1818** – *Transaction* to the Guadalquivir Navigation Royal Company of one of the largest marshland territories (Isla Menor) **1819/1849** – *Two acts* promoting irrigation agriculture among smallholders through tax exemption **1833** – *Forestry Bylaws* establishing the first protection system for forests	Persistent public deficit, but availability of private investment capital Developing of formal, but inconsistent policies and investment plans promoting the Guadalquivir Estuary and the surrounding left- and right-bank marshlands as a territory with a high commercial and economic potential (navigation, agriculture, colonization, mining) First works modifying the Guadalquivir River course, through meander cuts and the introduction of innovative industrial and engineering technologies (steam engine, mining). These processes are paralleled by the first attempts for drainage and agricultural development, which failed due to lack of adequate technology (e.g., left-bank Isla Menor marshlands) Public works for enhancing the Guadalquivir's navigability, granted to companies participated by private shareholders (e.g., Guadalquivir Navigation Royal Company)
r		19th century	LIBERAL REFORM ▼	**1851-1852** – *Series of Royal Orders* settling the project for making the Guadalquivir's navigable **1855** – *Madoz Disentitlement* nationalizing low-yield lands for privatization **1859-1862** – *Series of State regulations* entitling Forestry Engineering corps to catalogue excludable areas from the disentitlement process, partly alleviating forests from devastation (Forestry Catalogue) **1865** – Creation of the *Hydrographic Demarcations* **1866** – *Water Act* declaring water of public domain **1870** – *Channels and Reservoirs Act* granting large public-works companies perpetuity rights on the use of infrastructures in which they had invested	Increasing sale and/or public auction of properties (marshlands, scrublands and forests) of the so-called 'dead hands' (clergy and nobility) and beginning of extensive forestry operations (including extensive clear-cuts) across the State, owing to the disentitlement process (agricultural and paper-industry development) Agrarian Technical Reform at the State level – Increasing application of innovative technologies (e.g., impoldering) for the enhancement of agricultural productivity, based on middle-class and corporate private capital. High investment costs and long term recouping (land adaptation to irrigation and crop transformation) slows down technology implementation Increasing promotion of the need for water control (meander cuts, defense works) and regulation in the Guadalquivir Estuary (legal system) for enhanced navigation, communication, flood control and disease prevention

Ω’		2nd half of 1st third of 20th century (1900-1936)	LIBERAL STATE CONSOLIDATION ▼	**1870** – *Royal Order* promoting drainage engineering projects at the Lebrija marshes (most of them finished in 1928, due to inadequate planning and the priority given to navigation policies) **1877** – *Act* for the enhancement and afforestation of public forests excluded from the disentitlement process **1877** – *Royal Order* granting the first large-scale drainage works within the Doñana marshlands , at Aznalcázar´s Marisma Gallega (failed and reinstated in 1910) **1879** – *Water Act* giving priority to irrigation agriculture over navigation at the State level –end of laissez-faire policies.	Middle-class actors (naturalists, ornithologists and hunters) promote the Doñana marshes for naturalistic and hunting purposes (e.g. first expeditions of A. Chapman and W.J. Buck) and contribute to establishing its reputation as one of the most important waterfowl reserves in Europe (e.g. A. Machado y Núñez, H. Saunders, and Lord Lilford) Emergence of an intellectual-scientific movement termed ‘Regeneracionismo’, aimed at understanding the political, scientific, social and economic causes of Spain´s political and economic decline, largely in response to the loss of Spanish overseas territories Sustained conflicts between Civil and Forestry engineers, rooted in the poor discrimination of their respective responsibilities and their contrasting approaches to planning and management
Ω’ K	α-r		LIBERAL STATE CONSOLIDATION ▼	**1901** – Creation of the *Hidrographic-Forestry Demarcations*, precursor of the Water Authorities (1926) **1907** – *Colonization Act* halting emigration and promoting the cultivation of low-yield lands **1908** – *Protective Forestry Act* promoting afforestation of public and private forests **1911** – *Large Irrigated Lands Act* (Gasset Act) establishing the State as the financer and promoter of large public works **1916** – *National Parks Act* in 1916 creating the National Park’s Trust Boards **1917** to date – *Battery of regulations* implementing the park-based model **1924** – *Royal Order* of Ministry of Promotion granting a private financial group the drainage and exploitation rights of the Hinojos marshes (~10,000 ha.) **1926** – *Royal Decree* for the creation of the modern water authorities. **1927**– Creation of the *Guadalquivir River Authority*	Key figures of the ‘regeneracionismo’ describe regional differences in water availability as the main shortcoming for the development of irrigation agriculture, and promote a revised hydraulic-forestry policy as the panacea for economic development Beginning of the forestry protection-for-conservation policies and regulations in Spain. The Forestry Engineering Corps are entitled to catalogue areas to be protected from colonization and exploitation. Increasing links between nature (forests) conservation and forestry policies High GDP in Spain during the 1920s Increasing State interventionism through hydraulic policies and planning (e.g., National Hydraulic Plans of 1902 -Gasset Plan- and 1933), subsequently defended in several National Irrigation Congresses (1913, 1918, 1921, 1927, 1934) and paralleled by colonization strategies
			II REPUBLIC ▼	**1932** – *Irrigation Act* increasing the State responsibilities in the development of secondary and complementary public works **1935** – *Forest Heritage Act* promoting large afforestations with production purposes	Republican attempts for increasing public property in Doñana by declaring the marshes of ‘public interest’. However, lobbying by powerful stakeholders and private owners still succeed at promoting the drainage of several hectares of marshes for the culture of rice intended to supply the military Beginning of an intensive shift in jurisdiction in the private-property system, which increasingly goes to the State
Ω’ K	Ω’ K	century (1940-1975)	AUTARCHY* ▼	**1940** – *Act* entitling Forestry Engineering Corps for heading National Parks planning and management **1941** – Restitution of *Forest Heritage Act* declaring Huelva province (including Doñana) region of interest for forestry **1957** – *Forestry Act* entrusting the State Ministry of Agriculture with the stewardship of nature conservation and promoting production-driven planning and technologies	1940s – Increasing improvement of the Spanish economy – high GDP 1940s-1950s – First large-scale projects in Doñana, backed by the Gasset Act of 1911 (e.g. drainage of the Guadiamar River by the Guadalquivir River Authority, executed by public-private contract) 1950s – Massive afforestation projects promoted at the State level, both for production (Forest Heritage/Ministry of Agriculture) and for conservation (Directorate of Forestry/Ministry of Agriculture).

Ω'- α	2nd third of 20th	PROGRESSIVISM*	**1969** – *Doñana Act* creating the Doñana National Park (DNP), preceded by the purchase of 6,700 ha of marshlands by the World Wildlife Fund and the creation of the Doñana Biological Reserve and Doñana Biological Station (1964) by the Spanish Research Council **1971** – *Decree* dictating the merger of the Forest Heritage and the Directorate of Forestry within the Nature Conservation Institute (ICONA), which takes charge of the DNP's stewardship **1972 and 1974** – *Two Decrees* entitling the Institute for Agrarian Reform and Development (IRYDA) to implement large transformation projects in the marshes surrounding the DNP **1975** – *Nature Reserves Act* increasing the decision power of local administrations, land owners and the ICONA within the DNP's Trust Board, and favouring the agricultural projects of the IRYDA	1950s-1960s – First scientific expeditions of key national and international scientists (e.g., J.A. Valverde, F. Bernis), naturalists (e.g., G. Mountfort) and ornithologists (e.g., Roger T. Peterson) to the Doñana marshes, supported by private owners (e.g., M. González) who constituted key stakeholders in the protection-for-conservation processes 1970s – Implementation of the Almonte-Marismas Plan and Guadalquivir-FAO Project (preceded by the discovery and delimitation of the Almonte-Marismas aquifer) for the drainage of 35,000 ha of deltaic- and marsh-lands in Doñana, carried out by the IRYDA 1970s – Beginning of a long phase during which the conservation of the Doñana marshes depended on the organisational and personal relationships between the Doñana Biological Station and the ICONA, which was itself facing an internal power-contest between pro-conservation and old-school engineers
↘ ↙ Sync	3rd third of 20th century (1978-2000)	TRANSITION	**1978** – *Spanish Constitution* replacing the authoritarian government by a democratic government **1978** – *Doñana Act* increasing the Park's surface (50270 ha), and establishing novel guidelines for conservation inside and outside the park, and assigning the direction of the National Park and Biological Reserve to the ICONA (Ministry of Agriculture) and the Doñana Biological Station (Ministry of Education), respectively	1970s – 1978 Doñana Act extending the Park's surface, to include a strip of marine areas; launching a policy of expropriations to consolidate the public domain over most of its land; instituting an Use and Management Plan; setting the path for the establishment of a Master Plan for the regional coordination of socioeconomic development (e.g., road networks, tourist planning, agricultural and stock farming practices) and nature conservation; and allowing for the creation by law of the Doñana Natural Park buffering the core National Park (Nature Reserves Inventory Act of 1989).
K Ω' K		DEMOCRACY	**1981** – First *Doñana Hydraulic Regeneration Plan* aimed at the restoration of the main tributaries to the marsh (Guadiamar and Travieso Channels) and the modification of the Guadalquivir River levee, allowing to control the marsh inflow and discharges by means of sluices **1983** – *Water Act* implementing the Hydraulic Public Domain **1984** – First *Director Plan of Use and Management* of the National Park **1988** – First *Director Territorial Plan of Doñana* establishing a framework inter-organisational and stakeholder coordination in regional planning, and policy development and implementation **1989** – *Nature Reserves Inventory Act* creating the Doñana Natural Park (54250 ha) buffering the core National Park and the Andalusian Nature Reserves Network, henceforth stimulating and reinforcing the nature conservation legal system, and its protection standards and protocols **1993** – First *Doñana Sustainable Development Plan* **1998** – "Los Frailes" mining accident **1999** – *Doñana Nature Reserve Bill* aimed at taking over the DNP's management	1980s-1990s – Top-down drastic reductions in the irrigable surfaces established in the plans of the prior decades, which become more intensively used due to technological advances 1980s – First, failed hydraulic regeneration projects in Doñana 1970s-1990s – The DNP, fed by intensively modified tributaries and streams, is affected by progressive degradation and punctuated by ecological crises (e.g., waterfowl mortalities, biological invasions, mine pollution) and withstands a considerable number of pressures and threats both outside (e.g. irrigated agriculture) and inside (e.g. overgrazing by cattle and introduced herbivores, high risk of botulism outbreaks, deforestation of the inflowing stream basins with subsequent erosion of the banks) 1990s – First Sustainable Development Plan: increasing adaptation of the development policies to a changing reality, by developing compatible economic and conservation goals 1998 – Mining accident at Los Frailes, after which the Spanish government and the Andalusian government launched the Doñana 2005 and Guadiamar Green Corridor restoration projects respectively 1980s-2000s – The Andalusian Regional Government engages, and finally wins a political and judicial contest to claim jurisdiction over the Doñana National Park from the Spanish (central) Government
Ω' α-r? K?				

* Franco's dictatorship

Data collected from (in alphabetical order; see Literature Cited): Andrés-Gallego 1981, Borja et al. 2001, Casas and Urdiales 1995, Clemente et al. 2004, Cortázar and Vesga 1994, Cruz 1996, Demerson 1976, Enggass 1968, Fernández and Pradas 2000a, Fernández and Pradas 2000b, Fernández-Albertos and Manzano 2010, Fernández-Delgado 2006, García and Marín 2006, García-Viñas et al. 2005, Gómez-Baggethun and Kelemen 2008, Llamas 1988, Montes et al. 1998, Moral-Ituarte 1991, Moreno 1992, Ojeda-Rivera 1992, Ojeda-Rivera and Moral-Ituarte 2004, Orti 1984, Tomás y Valiente 1978, Valverde 2004, Zouwen 2006.