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Adaptive rationales and social-ecological complexity on insular tourism regions vulnerable to water stress

PHD CANDIDATE
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ABSTRACT

The aim of this thesis is to enhance our understanding of the complex relationship between humans and the natural environment and to investigate decision-oriented approaches that can navigate social-ecological complexity and promote sustainable development. The water-tourism complex and, more specifically, the link between water stress, tourism, climate change vulnerability, and water governance, constitute the empirical domain through which this thesis achieves its aim. The island of Rhodes in the Aegean is the laboratory (or case study) where the theoretical framework of the thesis is being applied for an empirical analysis that informs the theory. This thesis is organized into three chapters, written in the form of academic papers. The first paper uses the concept of complex systems as an analytical framework and, connecting it to planning theory, considers the implications of complexity into building planning mechanisms capable to respond to contemporary social and ecological challenges. It argues in favour of a 'complexity turn' in planning through the adaptive rationale (i.e. an additional, both normative and analytical, trajectory in planning theory, in the interplay between certainty and uncertainty). The second paper focuses on the complexity of the social and environmental relationships through the water-tourism complex. Following a social-ecological systems approach, it seeks to reply to the question of how water demand and governance interact with environmental dynamics to increase the vulnerability to water stress of insular tourism destinations. The analysis uses the island of Rhodes in Greece, as case study. The third paper further elaborates on the 'adaptation pathways' construct, originated in climate change research, by framing it to the management and governance of water resources in insular tourism regions vulnerable to water stress. This paper seeks to investigate the potential contribution of the 'adaptation pathways' framework in the building of adaptive Integrated Water Resources Management (IWRM) and governance approaches, which promote resilience to water stress and overall sustainable development for the islands under consideration. The theoretical analysis in the third paper is complemented with considerations on the tourism islands of the Southern Aegean Region in Greece using Rhodes again as an example. The thesis is based on a mixed research approach of secondary data collection and stakeholder interviews. The analytical framework is characterized by an interdisciplinary investigation on: complexity sciences, complex systems, planning theory, social-ecological systems, vulnerability, resilience, water and tourism, tourism studies, island studies, water management and governance, and climate change adaptation research. The main results of the thesis refer to: a) contribution to the definition of the adaptive rationale by calling for issue-driven adaptive approaches conceptualized through normative sustainability and nourished by post-normal science, b) development of the Water-Tourism Social-Ecological Systems (SESs) framework for the investigation

of water stress issues in insular tourism regions through a SES approach, and c) suggestion of the 'adaptation pathways for Water-Tourism SESs' approach as an additional lens to frame adaptive and integrated water-related decision-making for insular tourism regions bringing on board a place-centred perspective and based on the principles of the adaptive rationale.

INTRODUCTION

Today societies are exposed to irreversible and out-of-control changes of increasing rapidity and complexity (Minteer & Pyne, 2015; Steffen et al., 2015). These are multiple socioeconomic and biophysical changes that occur at different spatiotemporal scales and influence the interrelated components of social-ecological systems (SESs), leading to diverse outcomes in different places (Bennett, Blythe, Tyler, Ban, 2016). New approaches to decision-making are needed (Fazey et al., 2016) if planning is considered not only as a means to construct the (almost) unpredictable future but also as a means to navigate complexity and manage vulnerabilities and processes of adaptation to multiple interacting changes.

In this context of multiple social-ecological pressures, islands as unique ecosystems (Douglas, 2006), present a particular and increased vulnerability. Islands may vary in almost every aspect: geographical, ecological, political, social, and economic (Apostolopoulos & Gayle, 2002). Nevertheless, academic literature does seem to agree on some common development patterns undergone by islands, which are articulated in what we could call the 'insularity and islandness model'. Islands are commonly associated with conditions of smallness, remoteness, isolation, discontinuity, peripherality, vulnerability and dependency, summarized in a concept of insularity, which is used broadly to describe their geographic situation and their ecological, social and economic sensitivities (Christofakis et al., 2009; Coccossis, 2000; Benedictis & Pinna, 2015; Douglas, 2006). At the same time, these insularity features have been proven to be valuable 'resources' for islands and a key a comparative advantage for tourism through a stock of natural capital (Armstrong & Read, 2006; Sufrauj, 2010). In this case, the concept of islandness confers a positive connotation to the same attributes of insularity (Jackson, 2008; Sufrauj, 2010). As Conlin & Baum (1995, pp. 4) mention, 'the allure of islands, be they in the Mediterranean, the Atlantic or the Pacific, as places where people go for relaxation and rejuvenation, has a long tradition which continues unabated'. The insularity and islandness model as described above illustrates that islands are places that due to certain geographical attributes present inherent structural lock-in effects linked to constraints and opportunities for economic development (Wilson, 2013). These structural lock-in effects often later result in economic lock-in effects in the form of tourism monoculture, which largely affects their adaptive capacity, limits their adaptation options, and increases their vulnerability to external social-ecological pressures due to 'monofunctionality' and over-reliance on their environmental capital (Ibid.).

Considering the above, resources availability, and, particularly water availability becomes a main challenge for tourism islands. The pressure of tourism on water

availability becomes manifest at the local level, particularly in tourism hotspots such as small islands in the Caribbean and in the Mediterranean, where tourism is often the dominant water-consuming sector (Gössling et al., 2015; Hadjikakou, 2014). There, one can observe the main characteristics of the water-tourism complex: tourism increases the overall per capita water consumption and concentrates water consumption in space (often in arid regions) and time (often during the dry season) (Gössling et al., 2012). This mechanism, in combination with climate change, climate variability and water governance choices often makes many tourism destinations vulnerable to issues of water stress. Studies connecting climate change projections to tourism in European islands foresee a further increase of water supply problems in many tourism resorts, as temperatures increase and heat waves and periods of drought become more common (Sauter, ten Brink, Withana, Mazza, & Pondichie, 2013).

RESEARCH AIM AND QUESTIONS

The aim of this thesis is to enhance our understanding of the complex relationship between humans and the natural environment and to investigate decision-oriented approaches that can navigate social-ecological complexity and promote sustainable development. The water-tourism complex and, more specifically, the link between water stress, tourism, climate change vulnerability, and water governance, constitute the empirical domain through which this thesis achieves its aim. The island of Rhodes in the Aegean (Greece) is the laboratory (or case study) where the theoretical framework of the thesis is being applied for an empirical analysis that informs the theory. The main objective of this thesis is divided into three analytical research questions (RQs).

RQ1. *How to imagine new planning approaches upgraded by our latest understanding of planning through the complex systems?*
This first research question sets the stage of the thesis by using complexity and complex systems as an analytical framework challenging our understanding of planning. It aims to investigate the connection between planning theory and complexity sciences contributing to the latest attempts of moving beyond the question of whether some planning issues can be considered complex and start exploring 'methods of engagement and cognition' (Sengupta et al., 2016; Zellner and Campbell, 2015).

RQ2. *How do water demand and governance interact with environmental dynamics to increase the vulnerability to water stress of insular tourism regions?*
This second research question focuses specifically on the complexity of the social and environmental relationships. This research question aims to a deeper understanding of social-ecological relationships through the empirical domain of the water-tourism complex in insular tourism regions. In order to address this question, the case study is being employed.

RQ3. *How to formulate adaptive Integrated Water Resources Management (IWRM) and governance approaches that could promote resilience to water stress issues and overall sustainable development in insular tourism regions?*
This final research question induces the proposition of a potential strategy for the framing of adaptive and integrated water management and governance approaches that can promote resilience to water stress and overall sustainable development. Here, the theoretical analysis will be combined with considerations on the touristic islands of the Southern Aegean Region in Greece, Rhodes included. The analysis on the water-tourism complex (RQ2) will be now complemented by decision-oriented investigations to further inform RQ1.

THESIS ROADMAP

The aim of the thesis has been addressed with three chapters written in the form of academic papers. The roadmap of the thesis is presented in Figure 1.

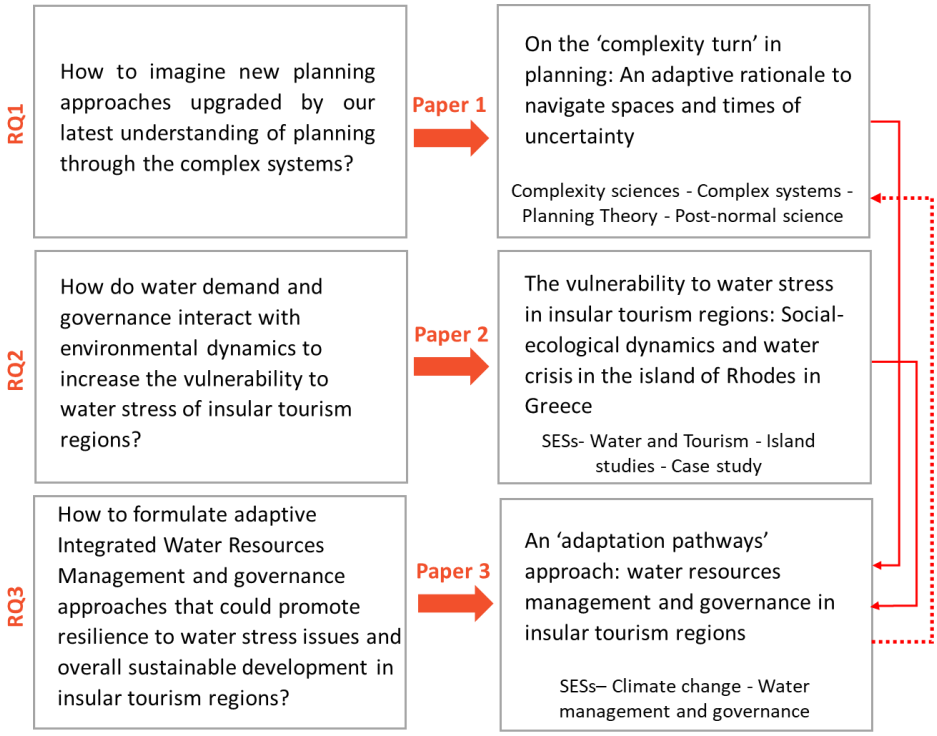

Figure 1 - Thesis roadmap. Source: Author

ANALYTICAL FRAMEWORK

This thesis profits from many complexity-related concepts and investigations that can be found across disciplines and formulate the broad 'sustainability sciences' field, which is better defined by the problems it addresses rather than by the disciplines it employs (Brandt et al., 2013). Thus, the analytical framework of the thesis is composed by contributions from different academic disciplines related to both of the so-called 'social' and 'natural' sciences: complexity sciences, complex systems, planning theory, social-ecological systems (SESs), vulnerability, resilience, tourism studies, water and tourism research, island studies, water management and governance, climate change adaptation.

Due to their different origins, the synthesis of complexity sciences with planning theories was a demanding task, which brought up creative tensions that have been rather useful for an in-depth investigation of the way complexity influences our understanding of planning (paper 1) and for initiating the building of this thesis following an exploratory approach. The synthesis of the water-tourism complex (paper 2) was another challenging task. This, because water and tourism research has been limited (Hadjikakou, 2014), often missing theoretical substance, which could be useful for this thesis. Although there are also studies that consider the broader sustainability implications of water use in tourism, a more integrated and dynamic understanding of the water-tourism complex as a complex social-ecological phenomenon still remains under-researched (see however Cole & Browne, 2015; Hof & Blázquez-Salom, 2015). At this point, the use of the SESs proved an important choice for the enhancement of the analytical framework of the thesis. The SESs, being in their essence complex adaptive systems (paper 1), are the underlying analytical force that connects the diversity of the scholarships used. The use of SESs as 'models of knowledge about real-world phenomena' (Becker, 2012, pp. 51) helps to emphasize the complex reciprocal relationship between society and nature and to analyze interdependencies between natural and social processes occurring at different temporal and spatial scales. In addition, SESs help to combine analytical with normative and value-driven approaches to systems thinking (see Glaser, Krause, Halliday, & Glaeser, 2012, pp. 197). The dialectics between analytical approaches and constructivist approaches permit the integration of 'ground-truthed' material phenomena such as water with abstract, non-material elements such as institutions, values or communication, throughout our research (Glaser, Krause, Halliday, & Glaeser, 2012). In paper 3, the parallel analysis of water management and governance approaches with climate change adaptation scholarship showcased the recent development of common premises, goals, concepts, and approaches between the fields. This allowed us to establish synergies between the fields' investigations and eventually offer a contribution that addresses both of them.

METHODS ON CASE STUDY SELECTION AND ANALYSIS

In this section, we explain main methodological choices that refer to the case study selection and analysis (see papers 2 and 3 in this thesis).

THE CHOICE OF THE ISLAND AS CASE STUDY

Tourism islands are interesting cases for the needs of our research, being particularly challenged by limited water resources availability due to their geographical isolation and the impossibility of drawing on more distant or diverse aquifers (Hof & Blázquez-Salom, 2015). Our focus on the tourism islands constitutes also a methodological choice connected to the SES approach. Ecology and biogeography consider islands as naturally confined systems and thus appropriate places for the study of systems dynamics. More specifically, the geographical isolation of islands' ecosystem processes has been proven useful for the identification and investigation of factors that affect species evolution and diversity (cf. Island or Insular Biogeography). In these scientific fields, islands have been used as natural laboratories already since the 1960s (MacArthur & Wilson, 1967). More recently, considering that islands are often popular tourism destinations, Hall (2015), among others, argues that their bounded nature has facilitated the detection, description and explanation of certain dynamics of tourism systems as well, and has contributed to the development of related theories (see for instance Apostolopoulos & Gayle, 2002). In this regard, islands have been used broadly as test fields to understand the impacts and implications of tourism on destinations. Thus, they offer unique conditions to conduct analysis through a (social-ecological) systems perspective and possibly identify systems' behavioral patterns and dynamics that could inform efforts like those of Ostrom (2007, 2009), Anderies, Walker and Kinzig (2006), and Cole and Browne (2015). Islands have also an additional 'attribute' that is considered useful for the needs of this thesis and is especially recognized in paper 3. Baldacchino (2007, pg. 6) recognizes the islands also as 'potential laboratories for any conceivable and uninhibited human project, in thought or in action' and as 'sites of innovative conceptualizations'. In this sense, islands are acknowledged not only as laboratories for the investigation of phenomena but also as test-beds for experimentation with, possibly innovative, interventions as the one proposed in paper 3.

THE CHOICE OF RHODES

The familiarity of the author with the Greek context directed the research towards the choice of one of the many Greek islands as case study. The choice of Rhodes, which belongs to the Southern Aegean region, was based on two main parameters. First, Rhodes has enough characteristics to be considered as an integrated 'model' of mainland areas because of a big size of land, the existence of an urban center, and rural peripheries and thus it could be indeed used as a 'laboratory'[1]. Second, due to the water situation and the tourism development on the island, we consider Rhodes an interesting case for the investigation of the social-ecological interactions and the vulnerability to water stress, according to the needs of our research. Rhodes is a major tourist destination within the Mediterranean, being a success story of mass tourism since the 1960s. Rhodes is not a typical case of 'the arid small islands' that constitute the majority of the Cyclades and Dodecanese archipelagos in Greece. Rhodes was considered an island rich in water resources that, however, in the last few years, faces evident issues of water stress. This situation, in the summer of 2017, resulted in a big water crisis. Although it is not only the development of tourism to be blamed for the water situation on the island, the intensity of the water problem in Rhodes correlates with the development and intensity of tourism, which is considered to be the most critical parameter affecting its water availability.

COLLECTION AND ANALYSIS OF PRIMARY AND SECONDARY DATA

Our research followed a multi-method qualitative research design. Semi-structured interviews, conducted during fieldwork between March and August 2017 in Rhodes and Athens, is the main research method used to collect our data. We conducted fifteen in-depth interviews of an average duration of 45 min each. The interviews were conducted in Greek and they were recorded, except moments when our interviewees asked to share 'off the record' information. Interviewees included policy makers working at the national, regional and local administrative levels, academics, local environmental activists, and a consultant from the private sector.

First, we conducted interviews in Athens. Interviewees were selected in function of their professional responsibilities, according to publicly available information from the Ministry of Environment, Energy and Climate Change, and knowledge on the topic of this research as referred in relevant secondary sources. Interviews in Athens provided a deep understanding of water governance in Greece, as well as of the country's water management challenges when referring to the water-tourism-insularity complex.

[1] This statement has been confirmed by the interviewees during the fieldwork.

Second, we conducted interviews in Rhodes with a selection of local actors identified through various information and reports gathered in Athens. Later in the research process, Rhodes island interviewees guided us through the local community and governance, opening up the field to sometimes not very accessible stakeholders or other people with knowledge on the issue under research. Although most of the interviewees were policy makers, each policy maker has at least a double role in the island: policy maker and local resident, policy maker and owner of touristic infrastructure, policy maker and farmer. The various roles of the interviewees' influenced our discussions with them and helped enriching this research with insights from different perspectives. Finally, these interviews provided an integrated understanding of the vulnerability to water stress in Rhodes and of the water governance challenges.

In addition to the interviews, during the fieldwork period, various secondary data were collected. Our primary data collection was thus complemented by the analysis of various policy documentations, scientific literature, local press and other reports, as well as with meteorological data. The gathering of secondary data proved a challenging task. First, we realised the lack of adequate data and documented knowledge concerning water resources' issues in Greece, especially when it comes to the local level[2]. For instance, in order to obtain results on meteorological drought in Rhodes and due to lack of already processed data available locally, we elaborated on meteorological data and performed the Standardized Precipitation Index (SPI) for Rhodes. A technician from DEYAR (Interviewee 1, 2017) commented 'I do not really have any tangible data to give you. We have everything here (showing his brain)' and, he continued, 'our technicians in the different villages of the island know well those places and work according to their empirical knowledge'. Moreover, our interviewees were often not aware of the existence of other secondary data, which we had identified through other channels, or they never managed to indicate an archive from where we could collect these data. In spite of the above, we collected sufficient and very relevant secondary data for this research.

In terms of data analysis, we transcribed the interviews and translated them into English. We organised this information in two groups: interviews providing general information on the issue of research for Greece and interviews offering specific insights into the island of Rhodes. We then focused on the interviews addressing specifically the case study. By using as a guide three interviews that we considered to provide information in a more integrated way than the rest, we identified similarities, differences, relationships and patterns, and we developed a small set of sub-themes (Miles, Huberman, & Saldaña, 2014). More specifically, we developed a group of themes that were cutting across all our different data

[2] For instance, both our research and the fieldwork confirmed the lack of monitoring of the water resources situation in Greece and especially the lack of data about water demand/consumption and availability. To calculate demand and consumption, policy documentation, scientific publications and other reports always use approximations based on the international literature (permanent population 150-200lt/person/day, tourists 300lt/person/day) rather than real water demand and consumption rates (Koutsogiannis et al., 2008).

sources, helping us to explore the phenomena more fully, provide greater depth, and to triangulate (Creswell, 2014). In sum, keeping the quotes as the basis, we conducted our analysis as a complex account of the sum of the collected data.

STRUCTURE

The thesis is organized in three chapters written in the form of academic papers and includes also a general conclusion. The summaries of the papers along with a brief summary of the main results are as follows.

Chapter1. Paper 1. On the 'complexity turn' in planning: An adaptive rationale to navigate spaces and times of uncertainty

Complexity sciences have been long ago acknowledged to be useful at conceptualizing a variety of phenomena relevant to planning. Nevertheless, the actual mechanisms that will prove adequate to tackle complex planning issues are still under debate. Considering that in today's so-called era of the Anthropocene such planning issues are more present and evident than ever, the need for further investigating the implications of complexity sciences into building planning approaches becomes very relevant. In this paper, we use the concept of complex systems as an analytical framework challenging our understanding of planning and we argue in favour of a 'complexity turn' in planning through the adaptive rationale. We define the adaptive rationale as an additional, both normative and analytical, trajectory in planning theory, in the interplay between certainty and uncertainty. Finally, to assimilate this rationale into planning mechanisms capable to respond to contemporary social and ecological challenges, we call for issue-driven adaptive planning approaches conceptualized through normative sustainability and nourished by post-normal science.
Paper 1 has been published as: Skrimizea, E., Haniotou, H., & Parra, C., (2018). On the 'complexity turn' in planning: An adaptive rationale to navigate spaces and times of uncertainty. Planning Theory. DOI: 10.1177/1473095218780515. The paper was conceptualized, designed, and written by E. Skrimizea. Professors H. Haniotou and C. Parra contributed in revising the manuscript.

Chapter 2. Paper 2. The vulnerability to water stress in insular tourism regions: Social-ecological dynamics and water crisis in the island of Rhodes in Greece

Tourism increases the overall per capita water consumption and concentrates water demand, in space and time, taking part in social-ecological processes that often result in the vulnerability of tourism destinations to water stress. Despite the significance of the issue, an integrated understanding of the water-tourism complex as a complex social-ecological phenomenon still remains under-researched. In this paper, we search for a deeper understanding of the water-tourism complex and its underlying governance, by means of investigating how water governance and water demand interact with environmental dynamics to increase the vulnerability to water stress of insular tourism destinations. Our analysis is based on literature on water and tourism, social-ecological systems, vulnerability and resilience, and island studies. It is focused on insular tourism areas and uses the island of Rhodes in Greece as case study. Results from in-depth

interviews with stakeholders and from secondary sources provide insights about the emerging vulnerability of Rhodes to water stress, spatiotemporal scalar mismatches of the social adaptations, and the transformation prospects of the Water-Tourism SES to a more sustainable tourism model. Taking into account that islands have been considered as 'natural laboratories', Rhodes could be considered as a laboratory capable to provide interesting insights for other Mediterranean islands as well.
Paper 2 has been submitted in the Journal of Sustainable Tourism.

Chapter 3. Paper 3. An adaptation pathways approach: water resources management and governance in insular tourism regions

Approaches to decision-making for adaptation need to be place-centred and to consider the multiple interacting changes that occur at different spatiotemporal scales, climate and global change included. With its origins in climate change research, the 'adaptation pathways' construct, as a framework for iterative and adaptive decision-making processes fostering adaptations over time, provides an interesting input to this end. In this paper, we further elaborate on the 'adaptation pathways' considerations by framing them to the management and governance of water resources in insular tourism regions vulnerable to water stress. Considering tourists, climate variability and change, and supra-island governance as major interacting drivers of change having an impact on the balance of a Water-Tourism social-ecological system (SES), we seek to investigate the potential contribution of the 'adaptation pathways' framework in the building of adaptive Integrated Water Resources Management (IWRM) and governance approaches, which promote resilience to water stress and overall sustainable development for the SESs under consideration. To do this, we base our analysis on literature on climate change, water management and governance, water and tourism, and social-ecological systems. We illustrate our theoretical analysis with evidence from the islands of the Southern Aegean Region in Greece, based on secondary sources and complemented by data from interviews with stakeholders. Our analysis proposes an additional lens to frame adaptive and integrated water-related decision-making for Water-Tourism SESs through a more place-centred rather than water-centred perspective. It also offers the vision of using the (Southern Aegean) islands as laboratories for an experimental implementation of such an innovative approach in order to gain more insights on how to address water stress issues in insular tourism regions.

Summary of the main results

In the conclusion, we discuss the main findings and results, the overall academic contribution of the thesis, the limitations and the questions arising for further research. The main results of the thesis refer to: a) contribution to the definition of the adaptive rationale by calling for issue-driven adaptive approaches conceptualized through normative sustainability and nourished by post-normal science, b) development of the Water-Tourism SES framework for the

investigation of water stress issues in insular tourism regions through a SES approach, and c) suggestion of the 'adaptation pathways for Water-Tourism SESs' as an additional lens to frame adaptive and integrated water-related decision-making for Water-Tourism SESs bringing on board a place-centred perspective and based on the principles of the adaptive rationale (normative sustainability and post-normal science).

CHAPTER 1

On the ‘complexity turn’ in planning: An adaptive rationale to navigate spaces and times of uncertainty

ABSTRACT
Complexity sciences have been long ago acknowledged to be useful at conceptualizing a variety of phenomena relevant to planning. Nevertheless, the actual mechanisms that will prove adequate to tackle complex planning issues are still under debate. Considering that in today’s so-called era of the Anthropocene such planning issues are more present and evident than ever, the need for further investigating the implications of complexity sciences into building planning approaches becomes very relevant. In this paper, we use the concept of complex systems as an analytical framework challenging our understanding of planning and we argue in favour of a ‘complexity turn’ in planning through the adaptive rationale. We define the adaptive rationale as an additional, both normative and analytical, trajectory in planning theory, in the interplay between certainty and uncertainty. Finally, to assimilate this rationale into planning mechanisms capable to respond to contemporary social and ecological challenges, we call for issue-driven adaptive planning approaches conceptualized through normative sustainability and nourished by post-normal science.

INTRODUCTION

The gradual increase of the world's complexity has been accompanied by a parallel progress in the scientific understanding of this complexity. Starting from fields such as biology, physics and mathematics, scientists began exploring the complex systems' behaviour, forming complexity sciences and theories, already by the 1940s (Castellani, 2013). Since 1970, the technological progress, concerning especially modelling tools, has played a catalytic role in developing the knowledge on complex systems and disseminating their usefulness (Allen, 2012). As a result, today scientists accept that almost all natural and social systems are interdependent, mutually interacting complex adaptive systems (e.g. a rainforest, the global economy, the world wide web, the immune system and a city) (Waldrop, 1992).

It then becomes clear that many issues, planning aims to address, can be considered to some degree as problems of complex adaptive systems (CAS). Indeed, complexity has been useful at conceptualizing a variety of phenomena relevant to planning (e.g. Baggio, 2008; Hall & Clark, 2010; Liu et al., 2007; McGreevy & Wilson, 2017). For example, Jacobs (1961), inspired by the progress in the life sciences, was perhaps the first to establish the link between complexity sciences and cities, by referring to the latter as 'problems of organized complexity'. According to Weaver (1948), 'problems of organized complexity involve dealing simultaneously with a sizable number of factors, which are interrelated into an organic whole' (pp. 539). The characteristics and dynamic behaviour of this organic whole cannot be reduced to the simple adding together of the characteristics and behaviour of its individual parts, and thus these are difficult to predict. Since then, Jacob's claiming has been studied and confirmed (e.g. Allen, 1983, 1997; Pumain, Sanders, & Saint Julien, 1989), recently mobilizing Batty (2010) to work towards a 'New Science of Cities' and Portugali, Meyer, Stolk, & Tan (2012) to discuss the development of the 'Complexity Theories of Cities' (CTC).

Nevertheless, it has taken time for planning to move beyond the question of whether some planning issues can be considered complex and start exploring 'methods of engagement and cognition' (Sengupta, Rauws, & De Roo, 2016; Zellner & Campbell, 2015). Subsequently, the actual mechanisms that will prove adequate to tackle complex planning issues constitute a very relevant issue still under debate. If the 21st century is the 'century of complexity', according to Hawking's famous quote back in 2000, planning seems to evolve accordingly and a growing number of researchers discuss today various aspects of the complexity-planning relationship. For instance, Innes and Booher (2010), focusing n the social dimension of complexity, propose their collaborative planning approach; Chettiparamb (2014) discusses fractal organization to understand self-similarity

in the organization of policies across scales; Moroni (2015), from an Austrian-Hayekian perspective on complexity, argues in favour of more generic frameworks for development based on urban codes. In a parallel – more developed but fragmented (Walker, Haasnoot, & Kwakkel, 2013) – literature focused on issues of natural resources management, the issue is addressed by constructing forms of adaptive planning (Arnold, 2010; Kato & Ahern, 2008; Van Buuren et al., 2013), adaptive management (Arnold, 2010; Patterson, Niccolucci, & Marchettini, 2008; Terryn & Boelens, 2013; Westley, 2002), adaptive policy-making (Haasnoot, Kwakkel, Walker, & ter Maat, 2013), and adaptive governance (Dietz, Ostrom, & Stern, 2003). At the same time, organizations of international influence are nowadays referring to the need for reconfiguring planning practices and policies in order to more effectively address 'complex global challenges', attributing to the term 'complex' (more or less consciously) its contemporary scientific dimensions (European Commission (EC), 2013; Organisation for Economic Co-operation and Development (OECD), 2009; United Nations (UN), 2012). Thus, the discussion is ongoing and new planning approaches are being formed, without however constituting part of the mainstream reasoning in planning theory or concrete and broadly applicable action plans (Boelens & De Roo, 2014).

In this paper, we attempt to integrate aspects of the complexity-planning Relationship dispersedly found in the literature in order to identify them as evidence and characteristics of a systematic 'complexity turn' in planning. We conceptualize this complexity turn to take place through the adaptive rationale – an additional normative and analytical trajectory in planning theory. On the 'normative' point, through our analysis, we argue on the need for this adaptive rationale, as well as the subsequent adaptive planning approaches, to be embedded within the concept of normative sustainability. Normative sustainability acknowledges a hierarchical relationship between the economy, society and the environment and recognizes democracy, social equity and social justice, cultural diversity and multiculturalism, and the maintenance of biodiversity as overriding societal values and goals. Furthermore, considering that the economy depends on healthy societies and ecosystems, normative sustainability criticizes the supremacy of markets and calls for a view in which the economy is subordinated to social and ecological constraints (Becker, Jahn, Stiess, & Welhing, 1997; Parra & Moulaert, 2011; Parra, 2013). By incorporating such a concept in our analysis, we extend critical questions already identified for the relative concept of resilience (Cutter, 2016) to the new generation of planning mechanisms: Adaptive planning for whom and for what? On the 'analytical' point, we argue that the complexity sciences and the adaptive rationale could bring issues of substance and the question of the approach to science within planning back to the forefront of planning connecting to the wider discussion on the type of science capable to respond to the uncertainties, as well as the irreversible and out-of-control changes brought by the era of humans or Anthropocene (Minteer & Pyne, 2015). Although a controversial term, in the so-called Anthropocene era, the transformations taking place in the Earth system (e.g. climate change,

biodiversity) are marked by increased complexity and uncertainty bringing new challenges to human viability and development. Our overall analysis integrates two aspects of complexity sciences often treated separately, which we call complexity sciences as 'extensions' or 'tools' of planning (mainly in terms of simulations) and complexity sciences as 'frameworks' for planning, and bridges the gap between the purely technical and the post-modern understandings of complexity in the planning field.

The paper is structured as follows. We start by analysing the example of cities as CAS. Then, we discuss the relevance of complexity to the spatial sciences and, through the concept of uncertainties, the implications of complexity for planning. This analysis sets the basis for the adaptive rationale, which is discussed in the last section revealing the analytical and normative aspects of a possible complexity turn. The paper is then brought to a close with concluding remarks.

PLANNING ISSUES AS COMPLEX SYSTEMS: THE EXAMPLE OF CITIES

One of the main objects of research complexity scholars have dealt with is cities[3] (e.g. Allen, 2012; Byrne, 2003; Pulselli, Pulselli, Ratti, & Tiezzi, 2005; Wensheng & Qiang, 2013). This could be attributed, in part, to the importance of cities (Allen, 2012; Portugali, 2012), being the living and working environment of over the half of the world's population and major generators, modulators, and recipients of global complexity. In addition, the city, being perceived as a territorial entity with its own history and specific characteristics that could remain generally unchanged for quite long time periods, is acknowledged to be an appropriate spatial level of reference for understanding various spatial processes through complexity (Pumain, 2006). Thus, we consider cities to be interesting, as well as useful examples of the way complexity is structured and manifested.

When referring to non-social complex systems such as natural ecosystems, the two main dimensions of complexity are considered to be space and time, while when referring to social complex systems the human factor is an additional dimension to be studied (Pumain, 1998). In fact, it is the human agency that largely defines the 'dual complex nature of cities' (Manson and Sullivan, 2006; Portugali, 2014): the city as a whole behaves as a complex system, but every human, part of this city, is also a complex system of self-organizing, adaptive behaviour. While in other kinds of CAS atoms and molecules can be described by their position in space only, every human has to be described by a number of extra features that play a role in his or her complex behaviour such as thoughts, intentions, cultural and socio-political norms, institutions, knowledge and interests (Portugali, 2006; Portugali, 2014). Subsequently, the social organizational structures, which are both emergent from and determinants of the individuals' actions, refer to collective entities (i.e. entities not reducible to the individuals' behaviour) characterized by some (complex) cognitive behaviour themselves (Bretagnolle, Daudé, & Pumain, 2006).

Cities' human agents are integrated with natural (biodiversity, seasonal temperature variations, climate change, etc.) and artificial (human-made structures such as buildings, roads, etc.) systems, which constrain and promote human actions and can also produce actions of their own. In fact, cities are considered unique types of CAS in that their spatial aspects and elements are also taking part in the human interactions, adding another layer of complexity

[3] We acknowledge that in specialized language the 'city' has been proven difficult to define. At this point of the paper, the 'city' refers to the common imageries created when the term is used in everyday language (e.g. densely inhabited territorial entity) and will be re-defined later through a complex adaptive systems (CAS) perspective.

(Sanders, 2008). In cities, space is not only a (social) end product, as it appears in social theory (see for instance Lefebvre, 1974) but it feeds back to and participates in the process of a socio-spatial production (see also Massey, 2005). Thus, the city is emerging as a CAS through the interactions of people, but once emerged, space functions as an 'order parameter' that enslaves (in Haken's language of synergetics) people's behaviour in a circular feedback process of human behaviour–space (Portugali, 2006).

The urban complexity does not lie only in the three elements – humans, space (the way we defined it for cities) and time – but also in the way these elements are organized. If one envisions the city as a multilevel system of semi-lattice structure (Alexander, 1965), there are many levels of sub-systems of diverse spatiotemporal scales, able to interact vertically, horizontally and sideways. To give life to these sub-systems and the interactions within and between them, Coward and Salingaros (2004) follow the example of electronic systems and organize the city into 'modules', that is, clusters of activities that have greater information exchange within the module than with other modules. The modules are referring to structured groups of links, where the actions carried out in different places in space communicate. This means that the term 'module' is more consistent with 'network' rather than with a spatially compact object or region (Batty, 2012; Coward & Salingaros, 2004). Thus, practically, the complex urban structure has to be understood not only with the strict visual arrangement based on the spatial footprint but also with the flow of information (Coward & Salingaros, 2004).

As recognized in second-order cybernetics, it is this flow of information that is crucial for self-organization and, subsequently, self-steering of the city-system (Karadimitriou, 2010). In the words of Portugali (2006), 'self-organisation is a process of information compression' (p. 658). The city's agents are continuously subject to a multiplicity of messages (to be perceived as results of 'informative perturbations' rather than information transmission – see Karadimitriou, 2010, p. 432) coming from other agents or from the broader environment of the city. They are then called to interpret or compress these messages and make a series of critical decisions from several possible alternatives in order to adapt their behaviour and feed back to their 'conversational partner' (Huys & Van Gils, 2010; Karadimitriou, 2010; Portugali, 2006). Perceiving each human to be also a complex system, it can be argued that self-organization in the city-system is dual: self-organization of an individual social agent and self-organization as mutual adaptation between agents (Portugali, 2014). The result of these local processes is the emergence of new a macroscopic behaviour or patterns which are (almost) unpredictable, due to the non-linear, multilayered and diverse actions and reactions.

The processes of self-organization and emergence are constant (i.e. always present in a more or less intense degree), meaning that the city is out of equilibrium, in a creative, dynamic situation (Batty, 2008, 2012, 2017; Portugali,

2012). These processes determine also the co-evolution of the internal and external environments of the city, or else the coevolution of the city and its (external) environment (Kauffman, 1993). In other words, co-evolution refers to the mutual and constant adaptation between all the systems shaping the city and its own ecosystem. It also refers to the long-term development of the city that, although restricted in an 'accessibility space'[4] (Bossel, 1999), it is largely unpredictable and necessarily about changes (either small adaptations or deeper ones, that is, transformations[5]).

With the latter concept of co-evolution we could go back in time, when Von Bertalanffy (1968) underscored the importance of open systems and their environments' role in their evolution, aiming at the study and understanding of living systems. In reality, we could accept that we are not referring to systems and their environments but to a living whole consisted of intersecting (complex adaptive) systems, the number and boundaries of which depend on the decisions we make for their study, according to our logical limits, perception and knowledge (Allen, 2001). A city could be perceived then as a socio-spatial entity of multilevel networks that compose its, subjectively and artificially defined, fuzzy limits, as well as an open-ended process, subject to gradual and continuous evolution (Bettencourt, 2013; Bretagnolle et al., 2006). The urban structures and processes are connected through a nested hierarchy of scales that link the microscopic level to successively larger scales and finally to the biosphere (Allen, 1997). Such an 'open' understanding of cities seems necessary in the Anthropocene, when what happens in cities is increasingly disconnected from their physical form (Batty, 2017) and couples the understanding of cities to global flows of information, resources, and ecological systems, which largely define their development.

[4] The accessibility space is being formed by the numerous constraints that restrict societal development. The total range of theoretical future development trajectories of a system is being restricted to a potentially accessible set of alternative states due to usually robust factors such as the laws of nature and the role of evolution (Bossel, 1999).

[5] Adaptation in the context of human dimensions of global change usually refers to a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity. (Smit & Wandel, 2006, p. 282). According to the degree of adjustment or change required from the original system there can be many levels of urban adaptation and thus there is also the possibility of transformation as a deep adaptation or else a 'substantial adaptation' (Smit & Wandel, 2006, p. 288).

THE RELEVANCE OF COMPLEXITY TO THE SPATIAL SCIENCES

Planning and, more generally, the spatial sciences[6] have formulated a particular relation with complexity. The first connections between space and complexity were already established around the mid-1970s not by planners, architects or geographers, but by physicists such as Prigogine, who used cities as an example to explain his theory of dissipative structures (Prigogine, 1977), and Allen, who revisited the classical location theory (Allen, 1981). From then on, researchers skilled in computational techniques (e.g. cellular automata, agent-based modelling and fractals) started constructing new methods and tools looking forward to establishing a complexity-informed theoretical basis for diverse spatial phenomena (e.g. Batty, 2010; Pumain, 2006).

However, researchers focused on the qualitative nature and social interpretation of the same issues remained sceptical in approaching the – 'hard sciences' originated – complexity sciences (Castellani, 2014; Portugali, 2012). They tended to be critical on whether ideas and concepts of complexity can be translated to the human sphere (Portugali, 2012). This scepticism seems that referred not to the essence of complexity but mainly to the controversial effectiveness of simulation modelling and, more generally, quantitative approaches, to problems involving the human behaviour (Portugali, 2012). It was only until the late 1990s that social sciences approaches engaged more systematically with complexity[7], integrating some social substance into the research on complexity sciences (Castellani, 2014; Urry, 2005).

At this point, it has to be emphasized that complexity is not only about quantitative messages (Byrne, 1998, 2003; McAdams, 2008; Portugali, 2012). Timmermans (2012, p. 186), using qualitative methods and a CAS perspective to examine the non-linearity in processes of planning practices is finally wondering 'Are there other ways than computer modelling to obtain quantitative data that support the occurrence of these non-linear steps? And even more fundamental: do we need quantitative data to understand nonlinearity in planning practice?' Nevertheless, as mentioned above, for years, socio-spatial systems' researchers focused on specific computational methodologies rather than the theoretical aspects of complexity, which were often neglected (Pumain, 1998). In fact,

[6] We perceive spatial planning as a hybrid of social sciences, natural sciences and engineering. When using the 'spatial sciences' term we refer to Geography, Urban Studies, Environmental Planning, Architectural Engineering, Geospatial Engineering and so on but it is spatial planning that we have mainly in mind.

[7] Approaches of complexity in the social sciences can be found even before the 1990s. However, both Urry (2005) and Castellani (2014) agree that the actual, more evident and robust social research on complexity took place in the late 1990s.

according to Portugali (2012), scholars working on urban complexity tended to ignore phenomena with not easily accessible quantitative data, thus, not useful for modelling simulations, restricting the potential production of knowledge and often making the contribution of complexity to seem outdated.

Today, there still is a remaining duality (Zellner & Campbell, 2015) reflecting perhaps a traditional gap between the quantitative, natural sciences–oriented, and the qualitative, social sciences–oriented, spatial sciences[8]. In fact, in a recent self-criticism on the CTC, Portugali (2012) observed a remaining trend of CTC to be narrowly defined as 'a new generation of quantitative urban simulation models capable of describing, simulatin and predicting urban scenarios in an efficient and accurate way'. Nevertheless, the distance between the aforementioned research trajectories has been certainly reduced by the many cross-disciplinary complexity-related concepts and investigations that formulate the broad 'sustainability sciences' field: resilience (Davoudi, 2012; Gunderson & Holling, 2002), social-ecological systems (Berkes & Folke, 1998), transitions (Rotmans & Loorbach, 2009; Van der Brugge, 2009), adaptive management (Kato & Ahern, 2008; Terryn & Boelens, 2013), adaptive governance (Folke, Hahn, Olsson, & Norberg, 2005), adaptive planning (Rauws & De Roo, 2016) and self-organization in bottom-up governance (Boonstra & Boelens, 2011).

The peculiar way in which complexity sciences have been integrated (or not) into the spatial sciences has not diminished their analytical power; they have important contributions to demonstrate, at least when it comes to the scientific analysis of sociospatial systems (e.g. cities)[9]. The situation is more complicated when it comes to planning, especially since this has lately evolved separately from the study of such systems (Batty & Marshall, 2012). 'In fact, design and planning as technical activities have tended to decline in significance, while planning practice has evolved as a form of negotiating, brokering, and facilitating which requires very different skills' (Batty & Marshall, 2012, p. 41; see also Zellner & Campbell, 2015). Therefore, when Van Wezemael (2010: 85) argues that 'spatial planning theory has quite some time ago reacted to the discovery of complexity, not least by putting communicative approaches and participatory methods at center stage' we cannot keep from questioning the degree to which such a movement is the result of a conscious integration of complexity sciences into planning, or if it mostly addresses the ambiguity (Zandvoort, Van Der Vlist, Klijn & Van Den Brink, 2018) and a quest for 'a more democratic and socially just planning process and practice' (Portugali, 2011b, p. 286). If we accept then that the contribution of complexity to planning has yet to be completely realized, could we perceive a more conscious integration of complexity sciences into planning as an opportunity for planning to evolve and further develop its scientific basis?

[8] See the analogy Portugali (2012) draws between 'the two cultures of science' and 'the two cultures of cities'.

[9] An analysis of these achievements is beyond the scope of this paper; see Portugali (2012, p. 48).

IMPLICATIONS FOR 'OUR UNDERSTANDING OF PLANNING'

Complexity, in the planning discourse, is still a fuzzy concept and it has been either unconsciously addressed[10], or it has been used as a literal term, lacking its scientific dimensions. De Roo (2010), performing a parallelism between the fuzzy understanding of sustainability in planning and this of complexity, argues that 'while the fuzziness of sustainability affects actions and behaviour in planning, complexity influences our understanding of planning' (p. 2). Indeed, if we recognize the notion of sustainability as more of a political and normative stance towards planning problems, then it differs very much from the actual and potential role of complexity sciences' theoretical principles and practical methods in planning. Taking into account that complexity has diverse key messages to offer depending on the perspective and focus of each researcher, we will discuss a major implication for planning, which challenges its basis, nature and definition: acknowledging and accepting the uncertainties that complexity implies.

ACKNOWLEDGING AND UNDERSTANDING UNCERTAINTIES

'Spatial planning is somewhere and long ago described as the best feasible mutual adaptation of space and society, such for the sake of society' (Van Veen Commission, 1973 according to Terryn and Boelens, 2013, p. 63), but also as a 'means through which we construct the future' (Byrne, 2003, p. 171). Hence, one could argue that in order for planning to be effective planners are called to absorb society's requirements and identify the way these can be integrated into space in the best, mutually profitable way (Allen, 2012; Terryn & Boelens, 2013). Following a first-order cybernetics approach to planning, the intervening planners observe, define and analyse the study area's past and present conditions to intervene in the present, aiming in the desired future (Karadimitriou, 2010). Combining the aforementioned socio-spatial complexity with such an understanding of planning, we can conclude that planning as a process and technical activity faces many challenges demanding a sequential understanding and processing of a series of complex presents so as to approach the desired future(s).

[10] It is important to note that we acknowledge that planning has generally worked in a complexity frame (Byrne, 2003; McAdams, 2008). However, in this paper, we argue for a more conscious application of complexity's insights in planning.

On this basis, uncertainty becomes a key concept in the planning process (Batty & Marshall, 2012; Byrne, 2003; Sela, 2016; Terryn & Boelens, 2013). The non-linear evolution of spatial processes is by itself enough to imply the uncertainties involved in their development trajectories. Moreover, one can understand that a complete understanding of each present and past and a perfect projection to and construction of the future are practically impossible, especially when considering the potential unforeseen disturbances too. The aforementioned inherent uncertainties of planning could be linked to two (of the three) kinds of 'unknowability' Marshall (2012) proposes as important consequences of complexity in planning: 'unknowability of the system as it is' and 'unknowability of effects of intervention' (p. 199). This means that an absolute knowledge of the system is very difficult to be achieved, and even if achieved, one would still be uncertain on how the system evolves with or without deliberate intervention (Marshall, 2012).

Things are getting more complicated when considering the uncertainty embedded in planning's goals for the desired future, what Marshall (2012) calls unknowability of optimal future state' (p. 200). To further argue on this kind of uncertainty, we will borrow from evolutionary biology the concept of fitness landscapes, which is used to visualize the development of a CAS over time (Kauffman, 1993; Richter and Engelbrecht, 2014). The fitness landscape for a specific system consists of an array of all the possible future states available to the system, illustrated as peaks and valleys. The peaks represent the 'well-adapted states' (Alexander, 2003, p. 17) or else 'an adaptive solution to a problem of optimization' (Lansing and Kremer, 1993: 104), where the fitness between the system and its environment is maximized. The valleys represent the less favourable states. The evolution of the system can be visualized as a journey across the fitness landscape with the tendency to locate the highest peak. When referring to complex socio-spatial systems – CAS such as cities – we are referring to a rugged (i.e. consisted of a number of different peaks), dynamic (i.e. changing peaks and valleys over time) fitness landscape. The potential optimal states are usually multiple (being socially contested, interpreted differently and subject to negotiation), continuously changing with time and thus possibly unreachable, and the journey towards there is certainly a challenge full of trade-offs (Portugali et al., 2012). 'A future city cannot simply be the built-out product of a creator's imagination, in the way a building can be. Nor is a city growing like an organism: there is no knowable optimal form of target organism to be steered towards' (Batty & Marshall, 2012, p. 44). Thus, which should be today's objectives of planning and, more importantly, who can guarantee that they will still represent a well-adapted state for the future city?

We argue that this latter uncertainty challenges some of the dominant aims of planning, such as this of the 'sustainable city'. For instance, despite the various meanings given to the concept of sustainability, we could agree that the prevailing conception concerns the achievement of a desirable state, usually equated to some kind of equilibrium or balance into the long-term future. However, according to what we discussed so far, cities' viability and evolution

seem to be dependent on their constant state of disequilibrium, while their well-adapted/sustainable states are changing and are likely to be unreachable. Indeed, when trying to go beyond the normative conceptualization of sustainability, sustainability concerns not a steady, subjective goal, but a dynamic concept that co-evolves along with societies' changing technologies, cultures, institutions, values and so on and is being continuously reassessed (Bossel, 1999; Swart, Raskin, & Robinson, 2004). In other words, according to our arguments so far, sustainability could be perceived as the continuously changing space of alternatives or paths in which it is desired for a system to evolve in, in order to ensure its viability over time. Such an approach to sustainability means that it is difficult to specify the optimal outcome in the first place (Marshall, 2012) and that the trajectory followed towards the objective becomes more important than the objective.

ACCEPTING UNCERTAINTIES AND INTEGRATING COMPLEXITY

Accepting that the spatial processes and planning effects remain largely unpredictable and deconstructing planning's goals can easily raise doubts about the purpose and effectiveness of planning. In other words, there is the risk for complexity to be considered as an unmanageable obstacle and for planning to be perceived as futile (Allen, 2012; Huys & Van Gils, 2010; Karadimitriou, 2010). However, complexity sciences do not validate the principle of laissez-faire as a means to effectively not plan a prosperous future. Complexity puts in the centre of the debate the rules that lead a system to a well-adapted state, or else to a peak of a fitness landscape, especially when it comes to non-natural systems, where the blind natural selection is not the case (Alexander, 2003; Portugali, 2006). In biological systems, the optimization occurs via blind natural selection (Lansing & Kremer, 1993). Nevertheless, a socio-spatial system is not an organism or, more generally, a (purely) natural CAS (Batty & Marshall, 2012; Bettencourt, 2013; Marshall, 2012). As argued already, these are results, at least partly, of deliberate selection (Lansing & Kremer, 1993; Portugali, 2006), which is co-produced by their complex adaptive agents and their natural and artificial elements: 'Multiple futures are possible, but social actions can influence the possible futures that will actually come to pass' (Byrne, 2003, p. 174). Thus, how can such a CAS be (deliberately) led towards a well-adapted state? The identification of these rules that can lead to a good adaptation is according to Alexander (2003) the most important scientific endeavour of our era.

In addition, the fact that a socio-spatial CAS has the ability to self-organize does not mean that the system, if left free to organize itself, will eventually reach a well-adapted state, at least not for all the agents that take part in the self-organization process (see, for instance, the tragedies of the commons). To build on this thought, as we already explained, humans organize themselves in complex systems, different than other living entities such as bird flocks or ant

colonies. They have the ability to understand and foresee, at least to a point, the development of the overall system and the consequences of their interactions; they have expectations and subjective opinions on the well-adapted states; they may prioritize their personal objectives over the group's objectives; and they are divided into strong and weak agents, following a hierarchy that has direct effect on their interactions (Boonstra & Boelens, 2011; Portugali, 2006). Subsequently, Karadimitriou (2010, p. 427- 428) argues that 'in the absence of any form of collectively sanctioned attempt to influence them, the spatial expressions of society will still evolve, most likely in a direction serving elites. The Victorians were the first to discover that in a capitalist world largely structured around power relations it is not a matter of whether we need planning, but a matter of what sort of planning we need'. Sanders (2008) acknowledges the neutral nature of adaptation, self-organization and emergence and, sharing the same concerns with Alexander (2003), questions the positive interactions that could lead to positive emergent patterns and overall positive adaptation of the system.

Hence, complexity does not render planning futile but calls it to operate using appropriately chosen theories, methods and tools, acknowledging the evolutionary nature of socio-spatial change and accepting its limitations (Batty & Marshall, 2012; Huys & Van Gils, 2010; Karadimitriou, 2010). The so far failures of planning should not be attributed to the complexity of socio-spatial processes, but to the fact that the planning theories and methodologies have been based mainly on a simplified perception of the reality (De Roo, 2010). This simplified perception regards either the denial of complexity and of uncertainty's existence, or the reflective action to restrict these 'barriers' by intensifying the processes of planning and control, deepening in more detailed methods and models, and ignoring the inherent uncertainty of complex spatial processes (Roggema, 2012). Today, the understanding of socio-spatial systems via the complexity sciences can of course bring new knowledge to the process of planning. The new technologies and the sophisticated computer simulation models will for sure ally in such a practice, as they become gradually capable of avoiding past forced simplifications (Allen, 2012; Bretagnolle et al., 2003). However, as it emerged from the aforementioned, more knowledge does not necessarily reduce the uncertainty embedded in complex spatial problems. Complexity refers (mainly and also) to a special category of uncertainties that cannot be approached through stochastic methods or by building scenarios, but instead have to be accepted as such (Roggema, 2012). These are uncertainties embedded in planning's objects, goals and methods that call planners to recognize their ignorance, as they are difficult to be assessed, being evidence of not fully understandable, at least until now, processes.

In light of these conclusions, we agree with those scholars who argue for a radical change in planning via complexity sciences insist that planning's aim should not be to reduce uncertainty and control complexity, but to understand and harness them to use new adaptive planning rationales and methodologies that will co-adapt and co-evolve with the dynamic spatial processes (Allen, 2012; De Roo,

2007; Terryn & Boelens, 2013; etc.). Keeping normative sustainability as a political stance we perceive complexity as a scientific basis, contributing to the shaping of planning methodologies that will make planning coexist with the uncertainties and participate in positively shaping complexity (Eraydin, 2013; Huys & Van Gils, 2010; Roggema, 2012). We are thus looking forward to a new field of study in which planning is not an external element of control, trying to impose a (dys) functional and (un)natural order in an otherwise spontaneous and complex urban process, but is taking part in this complexity as an integral element in its dynamics, positively influencing but also adapting to the systems' evolutions (Boonstra &Boelens, 2011). In such a field, planning will become a simultaneously flexible and robust process that will not aim at maximizing the planning result in line with the predefined goals but in optimizing the planning process according to the changing needs along open trajectories (De Roo, 2007; Hillier, 2010).

ON A ‘COMPLEXITY TURN’ IN PLANNING

The above reframing of planning leaves much freedom (and thus challenges) to researchers when trying to translate it in planning approaches. Besides, both the theoretical and practical integrations of complexity sciences in planning are major challenges, especially when considering that planning has originally evolved from a mix of philosophies and methods referring to determinism, reductionism and positivism (Byrne, 2003; Eraydin, 2013; McAdams, 2008). It is well-known that for years, the conventional view of planning concerned a regulatory mechanism that recognized the elements of space, along with humans, as stable, lifeless objects; it segmented the socio-spatial problems in independent units of work (i.e. closed systems thinking and sectoral specialization), and resulted in blueprints (McAdams, 2008; Timmermans, 2012). This technical perspective on planning may seem capable to tackle certain straightforward problems (e.g. building a road, power line or canal, etc.) but quickly raised doubts about its effectiveness to the many planning issues that are actually (at least to a degree) complex.

Nevertheless, when following the reasoning of De Roo (2007), which connects the successive shifts in planning theory to the gradual understanding of complexity’s needs, one can certainly acknowledge the progress that has been made in addressing the complex reality. According to De Roo’s reasoning, the latest crisis in planning resulted in the ‘communicative turn’ (Healey, 1992; Innes, 1995), which, bringing new theorists into planning theory (e.g. Habermas, Foucault, Dewey), attempted to respond to a number of stimuli, the ‘postmodern critiques of scientific rationalism’ included (Harris, 2002, p. 24). The communicative rationale underlying planning forms such as communicative planning (Forester, 1989), collaborative planning (Healey, 1997) and consensus building (Innes, 1996), is based on the assertion that the interaction among social agents is central to understanding and conducting planning (Innes & Booher, 2014). In contrast to the technical rationale, the focus here is on values rather than on facts: ‘the “facts” themselves are socially constructed’ and changing along with the participants’ re-considerations of ‘positions, interests and even values in the course of dialogue’ (Innes & Booher, 2014, p. 4). Thus, uncertainty becomes the starting point of planning since each agent is considered to be a ‘black box’ leading planners to seek certainty through interpersonal communication (De Roo, 2012).

Scholars, who investigate the integration of complexity’s insights into planning, acknowledge the potential of the communicative rationale and its relative forms of planning, first and foremost because they respect the fact that every ‘discussant’ is an agent and, thus, actually a planner, able to act and influence the evolution of the whole system (Batty & Marshall, 2012; Boonstra & Boelens, 2011; Byrne, 1998, 2003; De Roo, 2010). For instance, Innes and Booher (2010)

reflect (mainly) on the social complexity of today's planning issues and discuss the need for 'collaborative rationality' as an alternative to the traditional linear planning model. However, we would like to go beyond such a direct and absolute causality between complexity and the communicative rationale (as did also Allen, 1997; De Roo, 2007; Zellner & Campbell, 2015).

In a recent publication, Zellner and Campbell (2015) called planners to further develop their quantitative and computational skills in addition to negotiation and communication as they perceive complexity sciences to be an 'extension and technologically-assisted enhancement of communicative action' (p. 472)[11]. From this perspective, the focus is on using simulations for deeper understanding of the complex problem, of the interventions' cross-scale effects, and of the proposed solutions' robustness to support collective decisions and promote the negotiations. Expect from the 'embodiment of present knowledge' the simulations constitute also 'stimuli for learning' setting the planner more free in a virtual learning-by-doing adaptive process (Allen, 2001; Walker et al., 2013). Although we consider Zellner and Campbell (2015) to raise an important point on the complexity sciences' function within planning, we still miss some reflection on the broader 'organizational recipes' (Allen, 2001) that will embody such tools and will finally construct planning approaches capable to co-shape complexity as we previously argued for. Hence, instead of seeing complexity sciences as a mere 'extension' and an additional 'tool' of current (communicative) planning approaches, we aim to move a step further and discuss how they enhance the analytical and normative aspects of planning. Thus, taking into account research supporting that planning is currently undergoing a crisis and needs to pursue an additional trajectory[12] (Alfasi & Portugali, 2007; De Roo, 2012; Eraydin, 2013; Schoenwandt, 2012), we attempt to put forward aspects of a possible 'complexity turn' and of a subsequent new adaptive rationale (De Roo, 2007).

THE ADAPTIVE RATIONALE

De Roo (2007, 2012) describes the evolution of planning theory through the evolution of systems thinking and, more specifically, he attributes each planning rationale to the different classes of systems as identified by Kauffman (1993). According to De Roo's (2007, 2012) argumentation, the technical and communicative rationales could be perceived as the two ends of the planning rationales' evolution: the first end refers to the so-called closed systems, high

[11] Zellner and Campbell (2015) are explicit both about the importance of complex systems reasoning over the optimization of software or modelling codes and about the differences of their proposal from the previous (false) quest for comprehensive urban modelling.

[12] Supporting that there should not be the expectation to articulate a singular stance towards theories and methods in planning (Zellner & Campbell, 2015), the 'additional trajectory' does not aim to replace the known so far planning trajectories but to add in planning's toolkit in order to better address certain complex issues.

degree of certainty and an object-oriented perspective based on facts; the second end refers to very complex or chaotic systems, high degree of uncertainty and an inter-subjective perspective based on values. Following our analysis in this paper and further elaborating on De Roo (2007, 2012) and Boelens and De Roo (2014), a rationale aiming to address complex planning problems (i.e. complex adaptive systems that are characterized both by uncertainty and certain known behavioural patterns) should probably be positioned in a dynamic space in between these two ends, nourishing from both of them. As implied by the dynamic space, this non-linear or adaptive rationale (De Roo, 2007) calls adaptive planning to co-evolve with the spatial processes as an integral element in their dynamics. In this regard, the adaptability in the adaptive rationale formulates a both responsive and proactive integrated strategy constructed by a number of individual spatiotemporal planning solutions that aim to address specific situations and are especially concerned with the circumstances with which the object of planning might co-evolve (Boelens & De Roo, 2014).

Such a description of the adaptive rationale should not be misunderstood as an attempt to unify the technical and communicative planning rationales, satisfy the different proponents, and, subsequently, establish the adaptive rationale as a meta-rationale in planning theory. Instead, it should be regarded as an opportunity to bring up new debates, as well as to give more room to some already existing but somehow hidden discussions in planning when considering its future evolution. In this respect, the following important issue comes up: considering the position attributed to the adaptive rationale within planning theory, a main characteristic of the adaptive rationale could be the revision of the role of the planner and of his or her (scientific) knowledge in the planning process. More specifically, the adaptive rationale we argue for brings the discussion on the approach to science within planning, a discussion that had been crowded out by the communicative turn, to the forefront, and calls for facts and values in a dialectic relationship.

In fact, while the communicative generation in planning has been mostly engaged with the ‘short-term success of public deliberations’ (i.e. procedural fairness, inclusion and convergence towards consensus), the substantive success of the same planning processes has not been always ensured by a fair collective process alone (Innes & Booher, 2014; Zellner & Campbell, 2015, p. 460). Thus, the adaptive rationale could assist especially with substantive issues for which the ‘discursive problem-solving skills’ do not seem sufficient such as scalability, multiple forms of knowledge, highly technical information, cumulative impacts and unintended consequences (Zellner & Campbell, 2015). This also means that the planner’s role is upgraded and from a mere facilitator and mediator, as often seen from a communicative perspective, he or she is acting (also) as a scientist (not an expert) capable to navigate amid uncertainties (Zandvoort et al., 2018) and work deliberatively within imperfections (Funtowicz, 2006) to produce and/or manage changes (De Roo, 2012).

ADAPTIVE PLANNING AND POST-NORMAL SCIENCE FOR SUSTAINABILITY

Considering the characteristics we have attributed to the adaptive rationale, we argue here that adaptive planning can fruitfully be based on the post-normal approaches to science (Funtowicz and Ravetz, 1993). The post-normal science concept has been developed in contrast to Kuhn's (1962) 'normal science', underpinned by positivist philosophy, where 'uncertainties are managed automatically, values are unspoken, and foundational problems unheard of', as well as alternatively to the nihilistic response of post-modernity (Funtowicz & Ravetz, 1993, p. 740). It refers to issue-driven knowledge production marked by high decision stakes and extreme epistemological and ethical uncertainties, where the priority is to achieve quality in relation to outcome rather than a single truth (Frame & Brown, 2008; Funtowicz & Ravetz, 1993). As Funtowicz and Ravetz (1993) mention, post-normal science should be seen as a societal problem-solving strategy that partly draws on normal science, which however is no longer sufficient. Such an acknowledgement does not seek to undermine the importance of scientific research but to enrich it with the engagement of non-scientists and their own bodies of relevant legitimated facts and perceptions informed by diverse values and normative standpoints (Frame and Brown, 2008). In this paper, we have in fact followed a post-normal understanding of complexity sciences to explore their contribution to planning and it is this post-normal approach that builds the characteristics of adaptive planning. As mentioned earlier, the adaptive rationale to planning integrates the technical 'facts' with the communicative 'values' and calls them in a dialectic relationship within its epistemology. The reference to the 'dialectic relationship' is important since it implies an equal and issue-driven relationship between the two that will need to guide each other for the building of planning mechanisms, which, despite their inefficiencies, will be the most effective possible. In other words, there will be cases when the facts will dominate over the values and will guide or 'frame' the adaptive planning's content and process (e.g. when exact ecological tipping points have been identified), and cases when the high level of uncertainty, along the high decision stakes, will determine value commitments as 'hard' inputs, decisive for the setting of adaptive planning (e.g. when mitigating the effects of a possible sea-level rise) (Funtowicz & Ravetz, 1993).

Along with facts and values, the post-normal approach to complexity sciences includes ethics as well. As mentioned earlier in this paper, the 'neutrality' of complexity sciences' concepts is not any more relevant as these expand the scope of their concerns. Thus, the aforementioned 'how can such a CAS be (deliberately) led towards a well-adapted state?' is immediately complemented by subsequent inquiries concerning 'how to define a well-adapted state' and 'for whom will this be a well-adaptive state', which are inquiries of strong ethical dimensions and will determine aspects of the adaptive planning. Considering that the complexity sciences and adaptive planning are expected to assist especially with planning issues related to the various unsustainabilities brought by the Anthropocene, we can agree that today there is enough evidence to suggest the

need of planning approaches that will focus on the welfare of new stakeholders and new forms of equity among future generations, other species and entities, and the planetary environment in a global scale. In other words, there is enough evidence to suggest the need for planning approaches that will focus on normative sustainability. Thus, adaptive planning seems to demand an inherent normative sustainability stance within its epistemology, nourished by post-normal science and recently emerged, broadly controversial yet highly influential concepts related to the era of the Anthropocene such as the 'planetary boundaries', in order to be effective.

CONCLUSION

In this paper, we integrated aspects of the complexity-planning relationship dispersedly found in the literature in order to build up our argument on evidence and characteristics of a systematic 'complexity turn' in planning. We conceptualized this complexity turn through the adaptive rationale; an additional normative and analytical trajectory in planning theory that has yet to be defined. To contribute to the definition of the adaptive rationale and its operationalization, we argued for an adaptive planning with inherent normative sustainability stance within its epistemology, based on the post-normal approaches to science. Such a perspective on adaptive planning seems suitable for tackling the current complex, situation-specific as well as global, planning problems. The discussed adaptive planning approaches imply a (complex) planning system capable to be tuned with the complex planning issues – a task planning theory up to recently overlooked for not considering it a real scientific question13. Perceiving the use of space in some respects as a common-pool resource, the engagement of planning theory with the abundant literature of adaptive governance focused on natural resource management (i.e. governance system requiring structure of nested institutions and institutional diversity at the local, regional and state levels, connected by formal and informal social networks) seems both necessary and inevitable.

[13] Portugali (2011a) is an exception, having engaged with the question of a planning system not based on certainties and predictability, introducing the concept of the 'self-planned city' and the process of 'planning hermeneutics', which is an actual adaptive planning system.

CHAPTER 2

The vulnerability to water stress in insular tourism regions: Social-ecological dynamics and water crisis in the island of Rhodes in Greece

ABSTRACT

Tourism increases the overall per capita water consumption and concentrates water demand, in space and time, taking part in social-ecological processes that often result in the vulnerability of tourism destinations to water stress. Despite the significance of the issue, an integrated understanding of the water-tourism complex as a complex social-ecological phenomenon still remains under-researched. In this paper, we search for a deeper understanding of the water-tourism complex and its underlying governance, by means of investigating how water governance and water demand interact with environmental dynamics to increase the vulnerability to water stress of insular tourism destinations. Our analysis is based on literature on water and tourism, social-ecological systems, vulnerability and resilience, and island studies. It is focused on insular tourism areas and uses the island of Rhodes in Greece as case study. Results from in-depth interviews with stakeholders and from secondary sources provide insights about the emerging vulnerability of Rhodes to water stress, spatiotemporal scalar mismatches of the social adaptations, and the transformation prospects of the Water-Tourism SES to a more sustainable tourism model. Taking into account that islands have been considered as 'natural laboratories', Rhodes could be considered as a laboratory capable to provide interesting insights for other Mediterranean islands as well.

INTRODUCTION

The water system is today one of the most vulnerable earth's systems with the clean freshwater availability at higher risk than ever before. Tourism is largely dependent and, thus, affects water availability, both directly (in-room uses, laundry, irrigation, filling of pools, food preparation in kitchens, etc.) and indirectly (foods, energy, services, etc.). Referring to a big number of tourism regions where goods and energy are shipped or imported from other regions or countries, in this paper, our focus is on direct water use in tourism, i.e. water use at tourist facilities. Globally, tourism's average share in direct water consumption has been calculated at less than 5% of domestic use (Gössling, Hall, & Scot, 2015). The pressure of tourism on freshwater availability becomes manifest at a more local level, particularly in tourism hotspots such as small islands in the Caribbean and in the Mediterranean, where tourism is often the dominant water-consuming sector (Gössling et al., 2015; Hadjikakou, 2014). There, one can observe the main characteristics of the water-tourism complex: tourism increases the overall per capita water consumption and concentrates water consumption in space (often in arid regions) and time (often during the dry season) (Gössling et al., 2012). This mechanism, in combination with geographical specificities such as insularity, environmental dynamics and governance choices, often makes many tourism destinations vulnerable to issues of water stress. In this paper, we define 'water stress' as a region's state or tendency of inability to meet human and/or ecological demand for freshwater. In this sense, we perceive water stress as a subset of the 'water security'[14] concept and superset of the 'water scarcity'[15] concept. Adopting the definition by the CEO Water Mandate (Schulte & Morrison, 2014, p. 4), 'water stress considers several aspects related to water resources, including water availability, water quality, and the accessibility of water (i.e. whether people are able to make use of physically-available water supplies), which is often a function of the sufficiency of infrastructure and the affordability of water, among other things'. Hence, in contrast to water scarcity, which usually constitutes a numerical indicator measured across regions and/or over time, water stress also includes qualitative elements such as issues of governance and societal values.

Despite the significance of water in tourism development and the challenging impacts of this development back to the water resources, research on the topic remains limited and very recent (Hadjikakou, 2014). Water studies in tourism have so far focused on the consumption of freshwater in hotels and destinations,

[14] In general, 'water security is about managing water risks, including risks of water shortage, excess, pollution, and risks of undermining the resilience of freshwater systems' (OECD, 2013).

[15] Water scarcity refers to the lack of freshwater resources to meet water demand. It is a function of the volume of human water consumption relative to the volume of available water resources in a given area.

aiming to investigate ways for a more efficient use of the resource (e.g. Essex, Kent, & Newnham, 2004). This research focus mirrors a more general research trend within water scholarship, which is connected mainly to the natural and engineering sciences at the expense of research on crucial social dimensions that have also remained largely underexplored by the social sciences themselves (Braden et al., 2009). Although there are also studies that consider the broader sustainability implications of water use in tourism, a more integrated and dynamic understanding of the water-tourism complex as a complex social-ecological phenomenon still remains under-researched (see however Cole & Browne, 2015; Hof & Blázquez-Salom, 2015). Such an understanding of the water-tourism complex seems necessary in the so-called Anthropocene era[16], which calls for the recognition of problems relating to water security as complex, demanding not only technical approaches, but also more optimal governance and strategic decisions building resilience (Brugge & Rotmans, 2007).

In this paper, we search for a deeper understanding of social and environmental relationships through the angle of the water-tourism complex and its underlying governance, by means of investigating how water governance[17] and water demand interact with environmental dynamics to increase the vulnerability to water stress of insular tourism destinations. Our aim is to move beyond the usual analyses of water stress in tourism destinations as simple problems of increased water consumption leading to the depletion of the resource. Besides, current literature has revealed that such direct causal explanations oversimplify complex realities and are of little instructive value (Hummel, 2012). Thus, we propose an understanding that places emphasis on the intervening variables, and on contextual factors affecting the relationship between water stress and tourism. To achieve this aim, we follow a social-ecological systems (SESs) analysis and we attempt to combine analytical with normative and value-driven approaches to systems thinking (see Glaser, Krause, Halliday, & Glaeser, 2012, pp. 197). The use of SESs as 'models of knowledge about real-world phenomena' (Becker, 2012, pp. 51) helps to emphasize the reciprocal relationship between society and nature, and to analyze interdependencies between natural and social processes occurring at different temporal and spatial scales. The dialectics between analytical approaches and constructivist approaches permit the integration of 'ground-truthed' material phenomena with abstract, non-material elements such as institutions, values or communication, throughout our research (Glaser, Krause, Halliday, & Glaeser, 2012). In this sense, our work responds to the latest calls for a transition in water management towards more integrated systemic

[16] Although controversial, the term Anthropocene is broadly used today to denote the unfolding geological epoch in which human impacts have become profoundly established in the earth's dynamics introducing irreversible and deep changes and/or damages. In the so-called Anthropocene era, the transformations taking place in the Earth system (e.g. climate change) are marked by increased complexity and uncertainty and bring new challenges to human viability and development.

[17] In this paper, water governance will refer to 'the range of political, social, economic and administrative systems that are in place to regulate development and management of water resources and provisions of water services at different levels of society' (Global Water Partnership, 2002 cited in Rogers & Hall, 2003, pp. 7).

approaches (Daniell, Rinaudo, Chan, Nauges, & Grafton, 2015). In addition, we connect the issue of water stress to a tourism region's developmental choices, advancing the option of revisiting its water governance and overall development through the prism of normative sustainability (Becker, Jahn, Stiess, & Wehling, 1997; Parra & Moulaert, 2011; Parra, 2013).

Our analysis focuses on insular tourism regions and examines the island of Rhodes in Greece, as case study. Our focus on the tourist islands constitutes a methodological choice connected to the SES approach. Ecology and biogeography consider islands as naturally confined systems and thus appropriate places for the study of systems dynamics. More specifically, the geographical isolation of islands' ecosystem processes has been proven useful for the identification and investigation of factors that affect species evolution and diversity (cf. Island or Insular Biogeography). In these scientific fields, islands have been used as natural laboratories already since the 1960s (MacArthur & Wilson, 1967). More recently, considering that islands are often popular tourism destinations, Hall (2015), among others, argues that their bounded nature has facilitated the detection, description and explanation of certain dynamics of tourism systems as well, and has contributed to the development of related theories (see for instance Apostolopoulos & Gayle, 2002). In this regard, islands have been used broadly as test fields to understand the impacts and implications of tourism on destinations. Thus, they offer unique conditions to conduct analysis through a (social-ecological) systems perspective and possibly identify systems' behavioural patterns and dynamics that could inform efforts like those of Ostrom (2007, 2009), Anderies, Walker and Kinzig (2006), and Cole and Browne (2015). Furthermore, tourist islands are interesting cases for the needs of our research, being particularly challenged by limited water resources availability due to their geographical isolation and the impossibility of drawing on more distant or diverse aquifers (Hof & Blázquez-Salom, 2015). Focusing on the Mediterranean, an assessment of water issues on some of the biggest Mediterranean tourist islands underlined the importance of responsible water use and governance in order to ensure sustainable use of the water resources in accordance with the European Union Water Framework Directive (WFD) (Donta & Lange, 2008). Rhodes is a major tourist destination within the Mediterranean, being a success story of mass tourism since the 1960s. Rhodes is not a typical case of 'the arid small islands' that constitute the majority of the Cyclades and Dodecanese archipelagos in Greece. Rhodes was considered an island rich in water resources that, however, in the last few years, faces evident issues of water stress. This situation, in the summer of 2017, resulted in a big water crisis. Although it is not only the development of tourism to be blamed for the water situation on the island, the intensity of the water problem in Rhodes correlates with the development and intensity of tourism, which is considered to be the most critical parameter affecting its water availability. Due to the water situation and the tourism development on the island, we consider Rhodes an interesting case for the investigation of the social-ecological interactions and the vulnerability to water stress, according to the needs of our research.

The paper is divided into five sections. Section 2 provides the theoretical underpinning of this work, by constructing a conceptual framework for a SESs approach to vulnerability to water stress in insular tourism regions. This framework is based on literature on water and tourism, SESs, vulnerability and resilience, adaptation, and island studies. Section 3 provides the introduction to the Rhodes island case study and reviews the sources of data and means of analysis used in this research. The analysis of Rhodes is based on data collected from fieldwork carried out between March and August 2017, including in-depth interviews with various stakeholders and experts, and analysis of secondary sources such as policy documentation and reports. Section 4 discusses our findings on the water stress phenomenon in Rhodes revealing vulnerability trade-offs, adaptations' spatiotemporal scalar mismatches, and a subsequent water crisis along with its normative water governance and development planning aspects. The last section provides brief concluding remarks with a focus on the assessment of the SES approach we followed and issues for further research.

A ‘WATER-TOURISM SES’ TO CONCEPTUALIZE INSULAR TOURISM REGIONS’ VULNERABILITY TO WATER STRESS

The SES approach is based on the premise that SESs are complex, integrated systems in which humans are part of nature, meaning humans and nature belong to the same system and are entangled. Such a consideration is not trivial for the phenomenon under investigation. Although the fact that humans and water are linked through a system of mutual interaction has been recognized long ago, this has often failed to inform the scientific analyses and hydrological models in water resources management (Blair & Buytaert, 2015).

SESs include societal (human) and ecological (biophysical) subsystems in mutual interaction (Adger, 2006; Renaud, Birkmann, Damm, & Gallopín, 2010). These are considered to be open, dynamic, non-linear, coupled, adaptive, interdependent and interconnected across various spatial and temporal scales (Renaud et al., 2010). It is thus with no surprise that, notwithstanding the diversity of the analytical approaches used for their study, SESs are usually identified as complex adaptive systems, bringing complexity as a core theoretical challenge within their analysis (Becker, 2012; Renaud et al., 2010). In the last few years, numerous scholars have developed and tested conceptual frameworks applying complexity theory to research on SESs (Anderies et al., 2006; Ostrom, 2007; 2009; Renaud et al., 2010). In this paper, we use Ostrom’s (2007; 2009) complexity approach to SES - the Social-Ecological Systems Framework - which has been developed and applied to the analysis of forests, pastures, fisheries, and water, and very recently to the water-tourism complex (see Cole and Browne, 2015). Ostrom models a SES as a nested framework, following the multi-level, nested arrangement of a complex adaptive system. The SES is composed by four core subsystems: (a) a resource system; (b) the resource units; (c) the users of that system; and (d) the governance system (Figure 1). All these interact with each other and with the external environment. Each core subsystem is made up of multiple second-level variables (e.g. size of a resource system, mobility of a resource unit, level of governance, users’ knowledge of the resource system), which are further composed of deeper-level variables. This approach presents itself as methodologically quite robust addressing time-spatial trajectories, exchanges with other systems, endogenous governance system, and openness to "other" variables and tiers. The framework is also quite general and open to tailoring according to the needs of the social-ecological phenomenon under consideration.

Within the context of the Water-Tourism SES analyzed in this paper, a decision has to be made on the elements that can be considered as parts of the internal workings of the system (process) and those acting as external influences

(environment). Boundary judgements are a central issue when analyzing and modelling complex systems (Tretter & Halliday, 2012) and will necessarily introduce empirical conditions even into formal (mathematical) system analysis (Becker, 2012). The choice is usually determined by the research interest and approach, as well as by practical and operational considerations (Tretter & Halliday, 2012). An island, hosting clearly delimited terrestrial ecosystems including human presence, can be perceived as a naturally bounded SES yet porous, open to both positive events and threats (Jackson, 2008). As such, the island-SES in this paper includes aquifers, the related watershed and hydrological processes that determine the amount of water available on it; the relevant social counterparts including a diversity of users, infrastructure, governance systems, and cultural attributes; and is being considered together with its path-dependencies and path breakings (see also Cole & Browne, 2015).

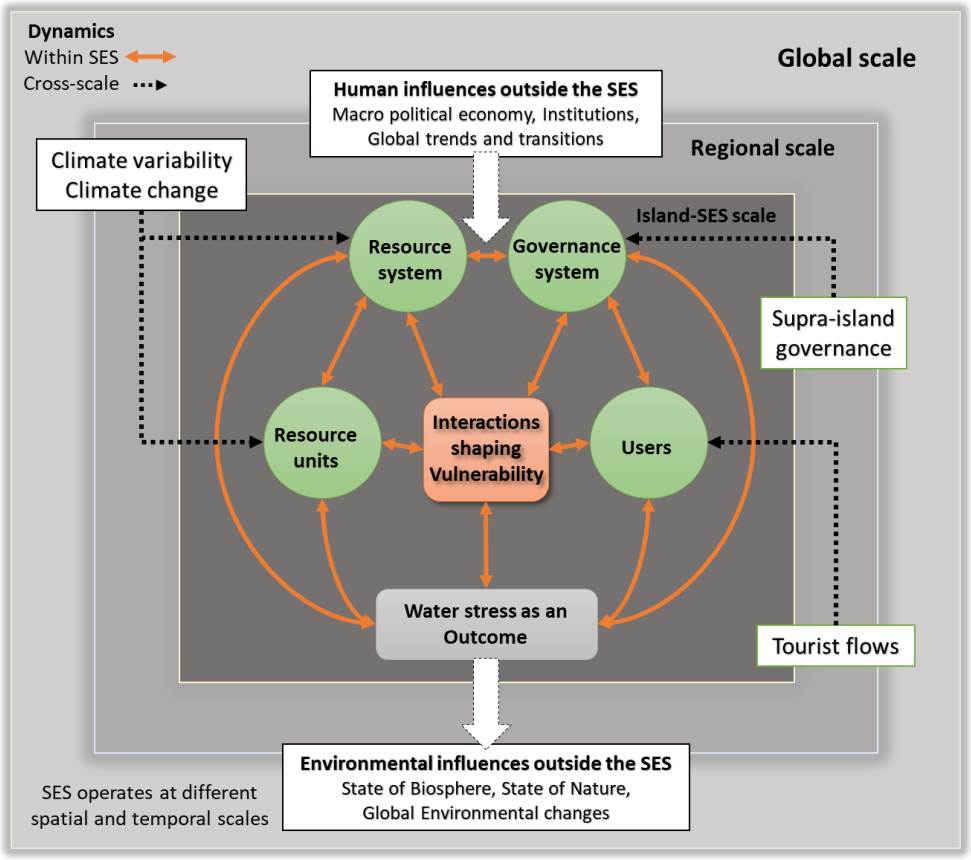

Figure 2 - Water-Tourism SES susceptible to water stress. The Water-Tourism SES framework is the result of a combination of the SES framework (Ostrom, 2009) and the Vulnerability framework (Turner et al. 2003). The spatial scales refer to geographical rather than politico-administrative scales. Source: Author, adapted from Ostrom (2009) and Turner et al. (2003)

This Water-Tourism SES refers to the destination without the tourists, who we consider to be drivers of change from the external environment (Figure 1). Tourists transform the system during a certain period of time and challenge its

internal processes and feedback control mechanisms. For the needs of this paper, the concept of 'tourists' refers not only to tourists as 'visitors' that simply add on the number of the permanent population but to the entire chain of direct water consumption that is mobilized with the arrival of tourists (in-room uses, laundry, irrigation, filling of pools, food preparation in kitchens, etc.). This assumption of ours is supported by the way most studies of water use in tourism have summarised direct water use in tourism, including the entire chain of direct water consumption per tourist (i.e. quantity water use in rooms, gardens and pool irrigation, sometimes even staff related water use) on the basis of litres per tourist per day. Scientific findings coincide that, although tourism may be very diverse across destinations and types of accommodation, in terms of the amount of water consumed and the uses of the water, the average global amount of water use per tourist per day (350lt/day) is substantially higher than the one of an average local resident (150lt/day) (Gossling et al., 2012; 2015). The magnitude of the tourists' demand, especially in comparison to domestic water use of a local resident, indicates the additional pressure that tourism puts on the water resources of a destination. This pressure mounts up with the spatial and seasonal concentration of tourism's water demand, which constitutes a major characteristic of the water-tourism complex in general, and of coastal and insular areas in particular (Essex et al., 2004; Gössling et al., 2012, 2015; Hadjikakou, 2014). The concentration of tourism in coastal resorts creates ephemeral localities of extremely high population density and, subsequently, high water demand. Bearing this in mind, we draw attention to the fact that tourism adds an extra dimension to the dynamics of SESs vis-à-vis the traditional, solely quantitative, approaches in the water and tourism literature. More specifically, Gössling et al. (2012) argue that tourism essentially becomes a problem analogous to the one of overpopulation. However, while overpopulation can cause some more permanent conditions, tourism has this very specific seasonality that adds in the complexity of the SES. In addition, tourism adds to the heterogeneity of users. The new users (tourists) have different water consumption patterns, often lack knowledge on the local water availability, and have greater socio-political power than the locals due to the economic importance of the tourism sector (Cole & Browne, 2015).

Other relevant drivers of change of particular interest to our Water-Tourism SES are climate variability and climate change (Figure 1). For many destinations, peak demand occurs in dry seasons, characterized by limited precipitation, warm climate, and restricted water availability (Eurostat, 2009). This can imply inverse relationships between water availability and water use (Gössling et al., 2015). Combined as well with periods of drought, this situation of water stress becomes especially pronounced on islands due to their often immediate dependence on precipitation and the practical difficulties concerning the use of transboundary water to compensate for water shortages. Climate change may alter the demand for water and the ability to distribute water to meet customers' needs, particularly at times of peak demand. It is especially the peak domestic demand that is very sensitive to climate change (Arnel & Delaney, 2006). Studies connecting climate

change projections to tourism in European islands foresee a further increase of water supply problems in many tourist resorts, as temperatures increase and heat waves and periods of drought become more common (Sauter, ten Brink, Withana, Mazza, & Pondichie, 2013).

As an additional driver of change, we identify the supra-island governance influencing the local governance of the Water-Tourism SES (Figure 1). This driver of change may be less relevant in the case that the island is a country (e.g. Cyprus) but it can be an important parameter for islands that constitute parts of countries' territories (e.g. the island of Rhodes). The supra-island governance as a driver of change refers to the dependence of the Water-Tourism SES governance on the regional administrative level and/or the dependence of the Water-Tourism SES governance on the national level, according to the way water governance is arranged and practiced in each country. Moreover, supra-island governance may refer also to institutional and governance influences originating beyond the national level such as the EU Water Framework Directive.

Summarizing, we identify four main drivers of change affecting the balance of our Water-Tourism SES: (1) Tourists; (2) Climate variability; (3) Climate change; (4) Supra-island governance. Climate variability and climate change influence directly the resource, tourists influence directly the users-group identity and behaviour, while supra-island governance influences the (water) governance on the island[18]. We perceive water stress as a possible outcome resulting from the whole of the interactions that formulate the vulnerability of a SES (Figure 1). Positioning vulnerability within the 'action situation' of the SES, being formed by both the social and ecological subsystems and the SES' context, is in accordance with the latest premises and findings of vulnerability research (Adger, 2006; Turner et al., 2003). Considering vulnerability as the result of the interaction among exposure, sensitivity and resilience (Adger, 2006; Turner et al. 2003), the human subsystem deals with the drivers of change through a set of adaptive capacities and responses (Chelleri, Minucci, & Skrimizea, 2016). For the needs of this paper we accept that 'adaptation in the context of human dimensions of global change usually refers to a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity' (Smit & Wandel, 2006, pp. 282). We also recognize that there can be many levels of adaptation according to the degree of adjustment or change required from the original system, and thus we include the possibility of transformation as a deep adaptation or else as a 'substantial adaptation' (Smit & Wandel, 2006, pp. 288). These responses-whether autonomous or planned, public or private, individual or institutional, tactical or strategic, short-term or

[18] It is evident that the reality is far more complex. For instance, climate change may influence the tourist flows and thus indirectly the users, the supra-island governance may also influence the tourist flows and indirectly the users, the tourists from their side certainly influence the governance choices etc. The Water-Tourism SES we propose constitutes a first step towards a SES approach to the water-tourism complex that we consider sufficient for the needs of this paper. It does not intent to be exhaustive and is subject to future research.

long-term, anticipatory or reactive, can have mitigating or amplifying effects to vulnerability for the different spatiotemporal scales of the SES.

Issues related to scale are of major importance when studying SESs, especially when assessing the effects of global forces such as tourism and climate change on a local SES level (Lauer et al., 2013). Moreover, issues of scale 'are not just tools for the study of phenomena, but are deeply rooted in the structuring of actions from personal decisions to global policies' (Vervoort et al., 2012, p. 1; Parra, 2010). Thus, the adaptive responses will collectively determine the vulnerability (and resilience) of the SES (or for parts of the SES) and may transcend the system of analysis, affecting other spatiotemporal scalar dimensions of the phenomenon with potential feedback on the Water-Tourism SES in question (Turner et al., 2003). In this context, the vulnerability to water stress has to be considered in its interaction with resilience as 'a set of related antagonisms' at different spatiotemporal scales (Propeck-Zimmermann, Saint-Gérand, Haniotou, & Skrimizea, 2018). The role of the SES governance as 'the complex system of regulation involving the interactions of a wide variety of actors, institutions, the environment and all types of socio-institutional arrangements at different territorial levels' (Parra, 2010, pp. 491)19, would be then to inevitably negotiate vulnerability and resilience trade-offs (Lauer et al., 2013) in order to frame for the Water-Tourism SES sustainable and flexible long-term development pathways linked to dynamic changes over time. Such a consideration, feed backs to the framework of Ostrom (2009), which exudes a strong belief in the rational logic of good governance that in the real world is not natural (Parra & Moulaert, 2011). Thus, in accordance with the criticism on Ostrom's framework by Parra and Moulaert (2011), here we consider the governance of the commons as a political process, rather than a rational process of (collective) management procedures as imagined by neo-institutional economics and imposed by New Public Management codes of conduct.

[19] Water governance is included in the overall governance of the Water-Tourism SES.

MATERIALS AND METHODS

In this section, we provide background information to the case study, the island of Rhodes, and explain the methodological choices of our research.

INTRODUCTION TO THE CASE STUDY: THE ISLAND OF RHODES IN GREECE

Rhodes, with an area of 1,401.46km2 and a population of 115,490 inhabitants (ELSTAT, 2011), is the largest island in the Dodecanese archipelago[20] and the fourth largest island of Greece (Figure 2). It is located in the eastern Mediterranean Sea, about 432 km southeast of Athens and very close to Turkey and its coastal touristic regions. Rhodes, comprising a 253 km coastline, is a hilly-mountainous island with the highest point being the peak of Mount Ataviros at a height of 1,216m in the western central part. A basic characteristic of the island's physical geography is a mountainous spine with a North East - South West direction that divides the island into two parts. The valleys of Rhodes account for 25% of the total surface (K/CH Ydatosustimaton Aigaiou, 2005). Administratively, the island is part of the South Aegean Region[21] and of the Regional unit of Rhodes[22]. Since January 2011, Rhodes forms a municipality consisting of 11 municipal units. The city of Rhodes is both the capital of the island and of the Regional unit of Rhodes. The city is located at the northeast end of the island and concentrates 44% of the population (50,636 residents) within an area that corresponds to the 1.46% of the whole island (Dimos Rodou, 2015). The rest of the island is mainly rural with a decreasing population density from the north to the south.

According to the Köppen-Geiger climate classification (Kottek et al., 2006), Rhodes has a Mediterranean warm temperate climate, with mild winters and dry summers. To identify Rhodes' local climatic characteristics, we gathered and examined information from the Climate Atlas of Greece 1971-2000 (Hellenic National Meteorological Service, 2016). In Rhodes, the high monthly average temperature is between 14.9°C in January and 29.5°C during the summer months of July and August. The low monthly average is between 10°C in January and

[20] The Dodecanese are a group of 15 larger plus 150 smaller Greek islands in the south-eastern Aegean Sea, off the coast of Turkey, 26 of which are inhabited.

[21] The South Aegean region is one of the thirteen regions of Greece. It consists of the Cyclades and Dodecanese island groups in the central and south-eastern Aegean Sea.

[22] The regional unit of Rhodes covers the islands of Rhodes, Chalki, Kastelorizo, Symi, Tilos and several smaller islands in the Aegean Sea.

February, up to 23.8°C in August. Precipitation is divided in two periods, the humid period of October-April and the dry period of May-September. The highest precipitation height, 140mm, takes place in January, although December (120mm) and November (110mm) are equally humid months. Precipitation during the summer months is very uncommon.

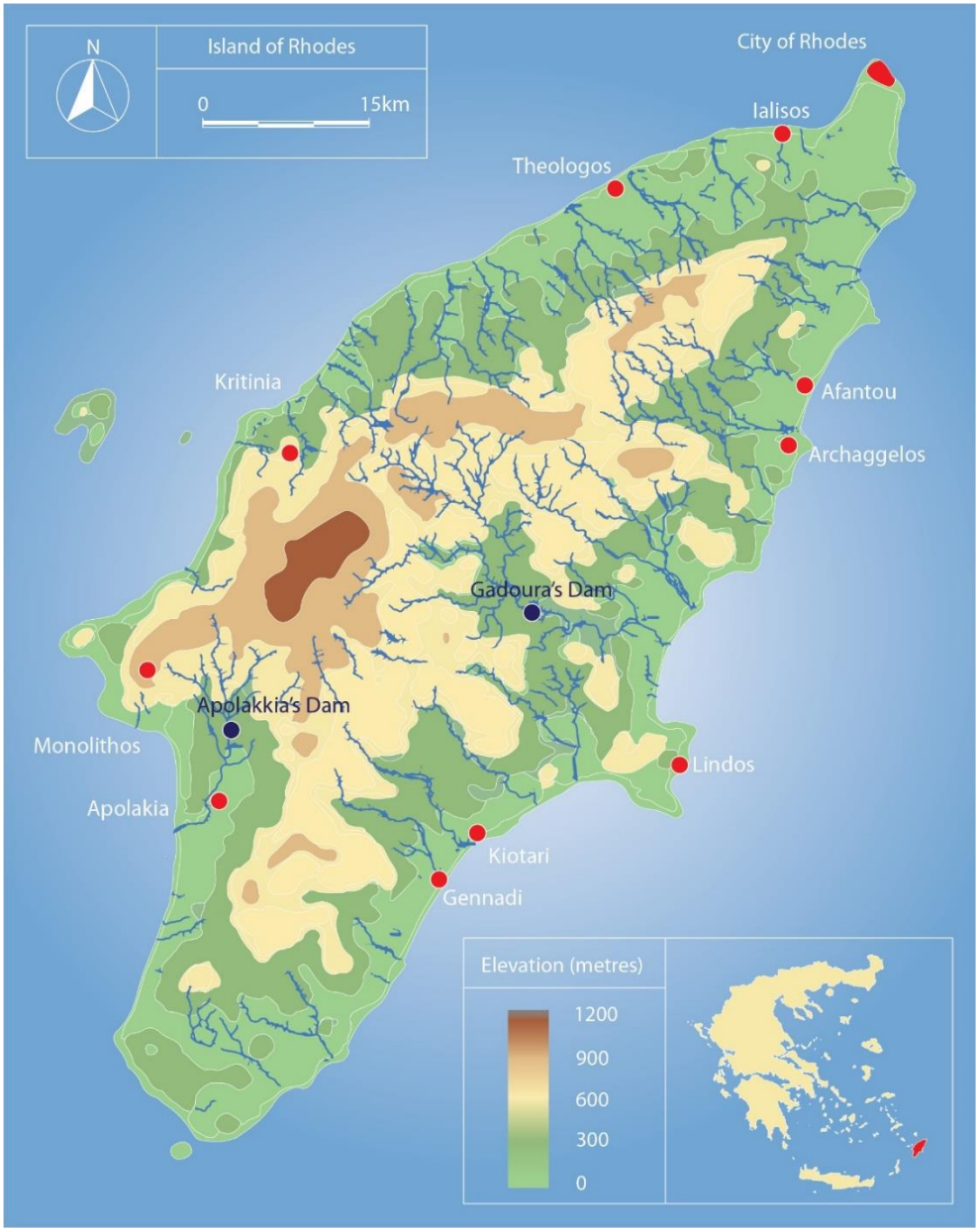

Figure 3 - Geophysical map of the island of Rhodes including the position of the city of Rhodes, two important dams (blue dots) and certain communities useful for the navigation of the analysis (red dots). The streams demonstrated on the map are only of temporary flow during precipitation. Source: Authors based on Google Earth and data from K/CH Ydatosustimaton Aigaiou (2005)

In Rhodes, the surface runoff does not present permanent flow and especially during the summer, when precipitation is mainly non-existent, the only watercourse on the island is Gadoura. Thus, the majority of Rhode's water needs are traditionally being served by groundwater through drilling. More recently, another source of water comes from the exploitation of surface runoff through the construction of dams. The Gadoura dam in Rhodes, constructed in 2015, is the biggest in the Aegean both in terms of the size of its embankment and the volume of annual runoff and capacity (Mihas, Oikonomidis & Tsialas, 2008). According to rough estimations, the main water use in the island is the domestic one (tourism included) reaching 18,657,500 m3/year, while the second main water use attends agriculture with a demand of 13,609,600 m3/year (K/CH Ydatosustimaton Aigaiou, 2005). Rhode's water service is under the supervision of the municipal organization DEYAR (Rhodes Water Supply and Sewerage Company). Rhodes constitutes an average case and representative example of the way water is managed in Greece. Over the last years, water needs are increasing and water abstraction projects seeking additional water provision, mainly new boreholes, have been broadly conducted by the DEYAR without any attempt for management policies to reduce demand (e.g. pricing policy, awareness raising) or promote water efficiency (e.g. loss reduction). Monitoring of the island's water resources began in the last few years through the River Basin Management Plans (implementation of the Water Framework Directive 2000/60/EC), conducted by the South Aegean Regional Water Authorities in collaboration with the Special Secretariat of Water, which is appointed by the Ministry of Environment, Energy and Climate Change and the Government.

Rhodes' tourism potential has been recognized already in the 1930s, at a time when the island was under Italian occupation. The contemporary tourism development of the island was initiated in the mid-1960s, after a rehabilitation period that followed the integration of Rhodes to Greece in 1948 (Logothetis, 2004). The Dodecanese evolved to become the most successful tourism destination in Greece, and Rhodes became the most popular of the Dodecanese islands. This development quickly made the Dodecanese one of the regions with the highest income per capita, and with very high rates of population growth in Greece (Logothetis, 2012). Although it has been argued that Rhodes' tourism product has exhausted its potential (Ibid.), the contemporary economy of Rhodes relies on mass tourism and related services. At a distance of about 12km north-west from the city, Rhodes Airport is the main gateway for visitors to the island. According to 2014 and 2015 data, Rhodes was the third airport in terms of arrivals from abroad (1,926,749 and 1,888,869 respectively), after Athens and Heraklion in Crete (ELSTAT, 2014; 2015). The fact that the island is consistently ranked among the first places in airport arrivals at a national level proves that Rhodes is an internationally recognized tourist destination that contributes catalytically to the Greek economy.

METHODOLOGY

Our research followed a multi-method qualitative research design. Semi-structured interviews, conducted during fieldwork between March and August 2017 in Rhodes and Athens, is the main research method used to collect our data. We conducted fifteen in-depth interviews of an average duration of 45 min each. The interviews were conducted in Greek and they were recorded, except moments when our interviewees asked to share 'off the record' information. Interviewees included policy makers working at the national, regional and local administrative levels, academics, local environmental activists, and a consultant from the private sector.

First, we conducted interviews in Athens. Interviewees were selected in function of their professional responsibilities, according to publicly available information from the Ministry of Environment, Energy and Climate Change, and knowledge on the topic of this research as referred in relevant secondary sources. Interviews in Athens provided a deep understanding of water governance in Greece, as well as of the country's water management challenges when referring to the water-tourism-insularity complex.

Second, we conducted interviews in Rhodes with a selection of local actors identified through various information and reports gathered in Athens. Later in the research process, Rhodes island interviewees guided us through the local community and governance, opening up the field to sometimes not very accessible stakeholders or other people with knowledge on the issue under research. Although most of the interviewees were policy makers, each policy maker has at least a double role in the island: policy maker and local resident, policy maker and owner of touristic infrastructure, policy maker and farmer. The various roles of the interviewees' influenced our discussions with them and helped enriching this research with insights from different perspectives. Finally, these interviews provided an integrated understanding of the vulnerability to water stress in Rhodes and of the water governance challenges.

In addition to the interviews, during the fieldwork period, various secondary data were collected. Our primary data collection was thus complemented by the analysis of various policy documentations, scientific literature, local press and other reports, as well as with meteorological data. The gathering of secondary data proved a challenging task. First, we realised the lack of adequate data and documented knowledge concerning water resources' issues in Greece, especially when it comes to the local level[23]. For instance, in order to obtain results on meteorological drought in Rhodes and due to lack of already processed data

[23] For instance, both our research and the fieldwork confirmed the lack of monitoring of the water resources situation in Greece and especially the lack of data about water demand/consumption and availability. To calculate demand and consumption, policy documentation, scientific publications and other reports always use approximations based on the international literature (permanent population 150-200lt/person/day, tourists 300lt/person/day) rather than real water demand and consumption rates (Koutsogiannis et al., 2008).

available locally, we elaborated on meteorological data and performed the Standardized Precipitation Index (SPI) for Rhodes. A technician from DEYAR (Interviewee 1, 2017) commented 'I do not really have any tangible data to give you. We have everything here (showing his brain)' and, he continued, 'our technicians in the different villages of the island know well those places and work according to their empirical knowledge'. Moreover, our interviewees were often not aware of the existence of other secondary data, which we had identified through other channels, or they never managed to indicate an archive from where we could collect these data. In spite of the above, we collected sufficient and very relevant secondary data for this research.

In terms of data analysis, we transcribed the interviews and translated them into English. We organised this information in two groups: interviews providing general information on the issue of research for Greece and interviews offering specific insights into the island of Rhodes. We then focused on the interviews addressing specifically the case study. By using as a guide three interviews that we considered to provide information in a more integrated way than the rest, we identified similarities, differences, relationships and patterns, and we developed a small set of sub-themes (Miles, Huberman, & Saldaña, 2014). More specifically, we developed a group of themes that were cutting across all our different data sources, helping us to explore the phenomena more fully, provide greater depth, and to triangulate (Creswell, 2014). In sum, keeping the quotes as the basis, we conducted our analysis as a complex account of the sum of the collected data and we organized it into three major themes that refer to each of the three sections of the results below: a) Water stress as an emerging vulnerability trade-off for tourism success, b) Adaptations' spatiotemporal scalar mismatches amplify Rhodes SES vulnerability, and c) A transformation for a new balance between tourism and environmental capacities.

RESULTS AND DISCUSSION

In this section, we discuss the results of our research on the Rhodes Water-Tourism SES, organized into three sections according to the three major themes that emerged from the analysis of the data collected. Figure 3 reconstructs the development path of Rhodes Water-Tourism SES and provides a summary that can help the reader navigate through our analysis.

WATER STRESS AS AN EMERGING VULNERABILITY TRADE-OFF FOR TOURISM SUCCESS

Water availability has diachronically been an issue for many Greek islands. The arid Mediterranean climate and the physical characteristics of the islands have put many limits to the availability of water resources. Nevertheless, Rhodes is not a typical case of such 'arid small islands' that constitute the majority of the Cyclades and Dodecanese archipelagos. The interviewees agreed that at least in the past, Rhodes was considered an island rich in water resources. During the Italian occupation (1912-1943) (Logothetis, 2004), Rhode's springs were sufficient to cover the city's needs. The growing water demand instructed the construction of boreholes and, since the island's big size and hydrogeological characteristics had put it in a rather advantageous position in terms of groundwater availability, water availability was not an issue for a long time. Despite the absence of surface runoff, the groundwater availability was enough to cover the demand and it is still this groundwater that is used up to today to cover the 99% of the island's needs (Interviewee 1 – Technician from DEYAR, 2017). In the words of Interviewee 2, an Environmental activist (2017),

> 'we are talking about an island that had water. I remember, in 1991, when I was taking part in a committee at a municipality, opening boreholes was an easy task. We could easily find water after just 50-60 meters of drilling.'

Nevertheless, already in the early 1990s, a study carried out by the United Nations Environment Programme (UNEP), cited by many of our interviewees, identified signs of saturation in different touristic places around the city of Rhodes. The study raised concerns regarding the effects of the island's unbalanced socio-economic development on water resources, ascribed to the growth of tourist activities and a concomitant accelerated rate of water use (Brachya, Juhasz, Pavasovic, & Trumbic, 1994). Similar concerns were raised during the same period by a hydrogeological analysis undertaken by the French

hydrologist Pierre Mutin, which were overlooked by the community (Interviewee 3 - Regional Public Official for Spatial Development, 2017). These two studies were conducted when the tourism sector was already established as an economic monoculture on the island. In 1982, the economic incentives provided by a National Development Law (1262/82) marked a period of rapid growth in the number of hotels on the island, which was not accompanied by proper regional planning. At the end of the 1990s, Rhodes had an officially declared capacity of 70,000 beds and was attracting 1.5 million tourists yearly (Logothetis, 2012). The Dodecanese became, in a short period of time, the most successful tourism destination in Greece and Rhodes, the most popular of the Dodecanese islands, was considered to experience the very much desired 'tourism miracle', as expressed by the local population (Ibid., 2012). Considering both tourists' preferences and the national policies promoting tourism development to be drivers of change to the internal processes of the Rhodes Water-Tourism SES, it seems that the local reactions captured (economic) opportunities, while creating new patterns of dependencies and possible lock-in effects (Wilson, 2014). As discussed in the literature (Chelleri, Minucci, & Skrimizea, 2016; Lauer et al., 2013), this process can bring up emerging vulnerability trade-offs that can lead to unpredictable, unwanted or unsustainable development trajectories in the long run. As expressed by Interviewee 1(2017),

> 'in the past we did not face any problems of water availability. There was a tendency of moving away from the city to construct new boreholes when the existing ones were not sufficient, either due to issues of pollution and salinization or due to new domestic water demands. The local population's water demand was increasing, tourism's water demand was increasing but we could easily respond to the needs by expanding our network of boreholes'.

This is a typical development pattern for many touristic regions, which have found themselves in a locked-in situation of serving an increasing water demand by increasing water supply. Normally, the over-emphasis on water supply management often leads to over-exploitation of the resource and underestimation of its value by its users, and consequently calls into question the overall long-term sustainability of a region's development (Brown, Keath, & Wong, 2009). Thus, according to our interviewees, in the last few years the island has been facing evident issues of water stress: the drillings today need to reach 150-200 meters for water to be found. Many of the groundwater aquifers have already been so heavily abstracted that present seawater intrusion and are no longer suitable for consumption. The 250 boreholes - rough estimation of the number of legal boreholes on the island – are not enough to cover the needs during the summer months. Although the development of tourism cannot be blamed as the only responsible for the water situation, the intensity of the water problem in Rhodes correlates with the development and intensity of tourism, which is considered to be the most critical parameter affecting water availability in many other Greek islands as well (Kizos et al., 2009).

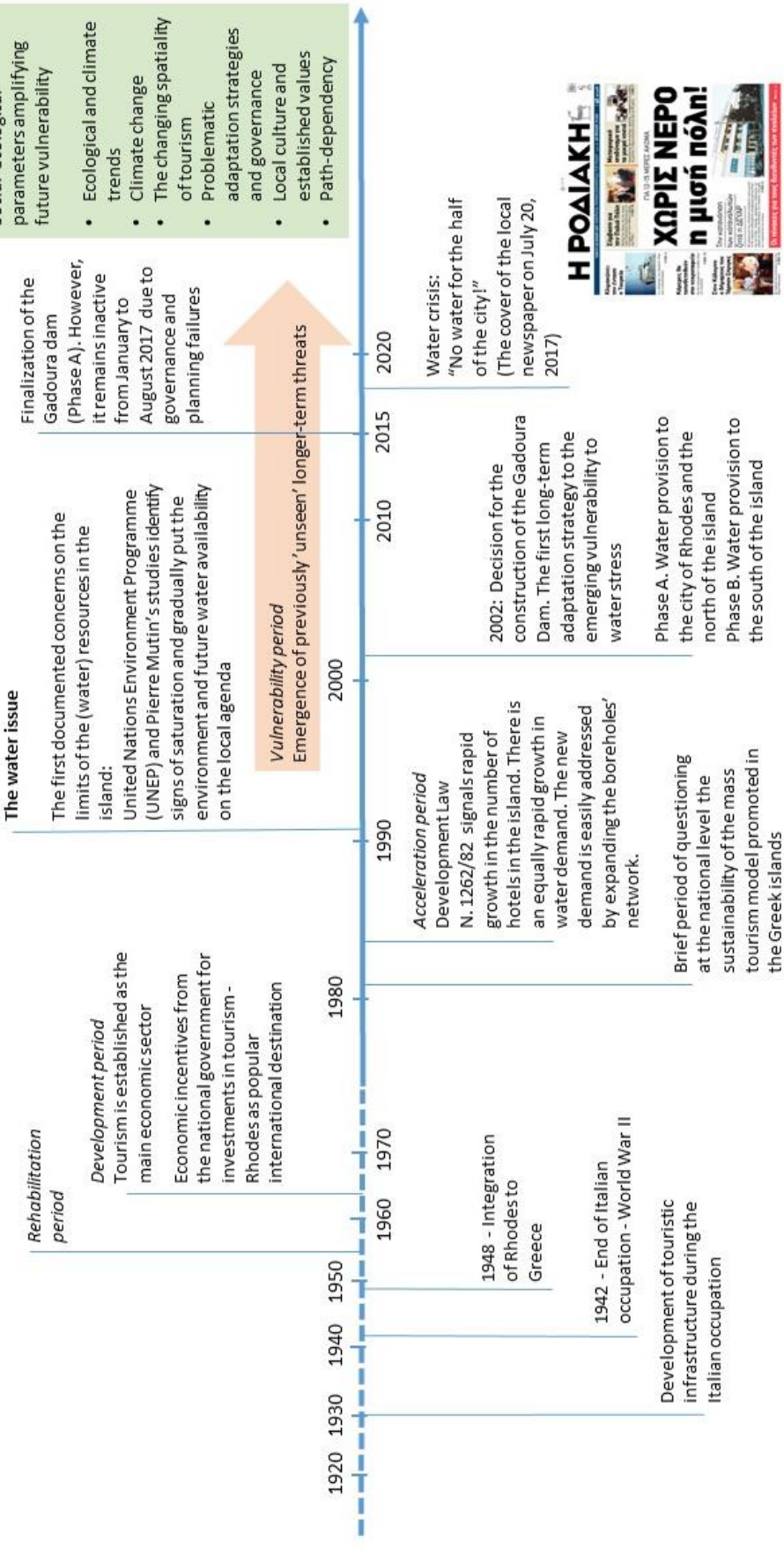

Figure 3 – The development path of Rhodes Water-Tourism SES and the emergence of the vulnerability to water stress. Source: Author

The decision for the construction of the Gadoura dam, which was taken in the early 2000s on the National and Regional administrative level, could indicate the will for a more conscious approach to water resources management in the island (Interviewee 4 - Municipal Public Official for Energy and Industry, 2017), putting into action for the first time a future-oriented long-term planning to complement the ordinary, everyday water management processes. This decision was the result of some reflections on the future water availability's capacity to cover the future demand in Rhodes with projections to the year 2039 (Interviewee 2 & 3, 2017). However, these reflections did not reach the local level that seems to be still absorbed by the 'tourism miracle' (Interviewee 3, 2017). In the words of Interviewee 5 - Anonymous (2017),

> 'Before even the building permit for the hotel comes out, there is a feasibility study for the hotel, which asks the community-village to supply water by permitting its connection to the local water provision infrastructure. Since the communities want the hotel, because people will be employed and the hotel will pay local taxes that will help the development of the community, they will provide water even if its availability is limited. In Kiotari, for instance, that they were building some large hotel units, they gave the water from three boreholes that could be used to cultivate crops instead but, in any case, they prefer to work in tourism than in agriculture. Unofficially we even know that along with the connection to the municipal grid, most of the hotels will also make a hidden drill… There is an informal understanding; we say, "Let's do this for tourism.'"

Thus, local communities appear to be consciously accepting the emerging vulnerability to water stress trade-off for tourism development, forming adaptation responses according to their values (Bennett, Blythe, Tyler, & Ban, 2016). In parallel, spatiotemporal mismatches in the adaptations to water stress formed by the regional and local authorities amplify the emerging vulnerability of the island to water stress, as it is discussed in the next section.

ADAPTATIONS' SPATIOTEMPORAL SCALAR MISMATCHES AMPLIFY RHODES SES VULNERABILITY

Social adaptations to drivers of change usually do not fully remove vulnerabilities, which are shifted spatially, temporally, or to a different kind of perturbation (Lauer et al., 2013). This because social adaptations often rise from competing perspectives and interests, levels of governance and sectoral focus; these interact between them and with the ecological dynamics, and often result in unwanted cross-scale effects (Matin, Forrester, & Ensor, 2018) and maladaptation (Burton, 1997). In the Rhodes Water-Tourism SES, such a mechanism is ongoing and rather evident, providing information on the action

situation of the SES.

Rhodes' local policy responses to the increasing water demand have been referring to the reactive construction of new boreholes, in the absence of an overall plan and monitoring of the water situation. This kind of responses or 'coping strategies' (Smit & Wandel, 2006) seem that temporarily reduced the system's sensitivity to water stress but increased its overall vulnerability in the longer term. Besides, the strong reliance on a single water supply, as it has been happening for years in Rhodes, has been identified as an important factor to increase the vulnerability of a system to water stress (Swart et al., 2012). As discussed above, on a national and regional level the need for an alternative approach to water resources management in Rhodes was already identified in the early 2000s and referred to the construction of the Gadoura dam. As Interviewee 2 mentions,

> 'The Gadoura Dam, which has been a really ambitious infrastructure in terms of its capacity (67,000,000 m3 that corresponds to the ¼ of the island's total surface runoff), was a decision taken because there was a forecast that in 2039 we would need 25,000,000 m3 to cover the domestic water needs of our island for a year and the dam would be sufficient to cover the whole of these needs. The dam was especially made to take into account the water needs of tourism and make sure to cover the peak demand.'

The official decision for the construction of the Gadoura dam was taken in 2002. This plan was composed by two functioning phases of the dam: Phase A concerns the construction of the dam and water provision to the city of Rhodes, as well as to the 'northern touristic triangle', as it is called by the locals, of Ialysos-Rhodes city-Faliraki. Phase B refers to the construction of the network that will supply water from the dam to cover the domestic needs of the south part of the island (until Gennadi). This quest for a diversified water supply and the transition to a proactive planning of longer-term courses are certainly valid attempts to reduce Rhode's vulnerability to water stress. However, the actual efficiency of such an adaptation strategy should be understood in conjunction with a number of other factors.

The dam's construction was finalized in 2015. The dam supplied with water the city of Rhodes and other areas in the north until December 31st, 2016 but then remained inactive until August 2017. The inactivity of the dam has been attributed to operational problems due to problematic co-operation between the regional administrative level, which was responsible for the construction of the dam, and the municipality and DEYAR, which are responsible for its maintenance and the necessary infrastructure for the distribution of water. The dam was constructed but DEYAR lacked the necessary reservoirs and infrastructure for the exploitation of the water (Interviewee 2, 2017). It is a common situation in the Aegean islands for many dams and reservoirs to face operational problems that

make them unusable and inactive. Municipalities often lack the financial resources and the qualified staff to ensure the proper maintenance and operation of the dams (Mihas, Oikonomidis, & Tsialas, 2008).

During the summer of 2017, when our fieldwork was conducted, the island was experiencing important water deficiencies. According to the interviewees, the island was facing probably its biggest crisis in its history in terms of water (un)availability. In a public announcement, DEYAR confirmed the urgency of the situation and made a call to the communities to minimize their domestic and agricultural water use. DEYAR also attributed this water crisis to the declining precipitation, the declining groundwater levels, the increasing touristic demand, and the inactivity of the dam. According to DEYAR (2017),

> 'The water needs for the city of Rhodes and the touristic areas of the north reach the 2,500m3/hr. From these, our boreholes can cover up to 2,100m^3/hr. Last summer, this deficiency was covered by the Gadoura dam, which is currently inactive. The water problem on the island is due to the increased demand that cannot be covered by the boreholes alone anymore.'

According to all the interviewees at the local level, this water crisis is probably the first time that the local communities became aware of the actual vulnerability of the SES to water stress. 'In certain areas households are remaining for 10-14 hours without water provision due to the inability of the system to respond to the peak demand tourism induced. People finally see the extent of the issue in their taps.' (Interviewee 2, 2017). 'This was a phenomenon that could emerge during certain days in August but now it is much more intense and we also started seeing it much earlier in the touristic season' (Interviewee 1, 2017). Thus, one could say that the inactivity of the dam finally revealed the extent of the vulnerability of Rhodes to water stress. At the same time, it confirmed the need for an additional/alternative approach to water resources management, and, most importantly, the rather marginal match between the temporal scale of the institutional implementation of the adaptation action (dam construction and functionality) and the evolution of the needs (a function of groundwater depletion and water demand).

The second functioning phase of the Gadoura dam, concerning the conduction of infrastructure to provide water to the south of the island, is still in the process of obtaining the necessary funding which, especially due to the impacts of the global economic crisis on Greece, seems a difficult and time-consuming process. Thus, the Region has communicated to the local authorities that this will be a long-term process of uncertain time horizon. This situation, in combination with the evolution of the spatial distribution of tourism development on the island, has raised concerns about a new vulnerability arising in the south, where 90% of the new hotel infrastructure is being constructed (Interviewee 2, 2017). More specifically, tourism in Rhodes since the beginning of its development has been

concentrated in the northern part of the island, which has left the south rural and free from mass tourism flows until recently. In the words of Interviewee 1 (2017),

> 'In the south of Rhodes, there are small villages where we notice a rather important tourism development trend. The areas of Kiotadi and Gennadi are today areas of intensive tourism growth that takes place through the development of luxurious hotel infrastructure. Thus, there, we are expecting a huge growth in water demand that we had not foreseen. To explain, around these areas during the last ten years we have the construction of around eight new five stars hotels with capacities of 700-800 persons each. This is like to say that in a decade in the south of Rhodes we suddenly have 2-3 new villages to provide water to. We will have at least 6000 beds of high water demand and this is a big issue that bothers us already.'

DEYAR is currently in a process of ensuring that the necessary infrastructure and reservoirs are in place yet without guaranteeing that the available water will cover the demand in the south. It is still unclear whether new boreholes will be made in areas that already suffer from salinization, or other ways of water provision should be found. Interviewees attributed the situation to a problematic functioning of the multi-level governance of the SES that leads to scalar conflicts and mismatches between the Regional planning and the local evolutions and needs, as reflected in the following quote:

> 'The national and regional level plans do not match our needs. If we need almost 20 years for the dam to be decided and constructed in its first phase (i.e. water supply to the northern triangle), one can understand that considering the time-scales on the ground this kind of planning can already be outdated.' (Interviewee 1, 2017)

The aforementioned analysis confirms Castro et al. (2018) who emphasize the lack of implemented solutions to address water stress associated with cross-scale and cross-sectoral SES interdependencies but most importantly, raises questions about the future of the island. Thus, the next section puts into question Rhode's long-term future, incorporating the climate change factor.

A TRANSFORMATION FOR A NEW BALANCE BETWEEN TOURISM AND ENVIRONMENTAL CAPACITIES?

According to the tourism and water resources perspective we have followed in this analysis, one could say that the island of Rhodes is today at a bifurcation point regarding its water resources management approach and overall development trajectory. Results from our fieldwork research revealed that in the summer of 2017 the island underwent a big water crisis, as manifested in the

local press, in extensive meetings among regional and local authorities, and everyday discussions among the local population. Transition studies have shown that such crises can sometimes be the catalysts for the destabilization of existing management regimes providing windows of opportunity for change (Birkmann et al., 2010). Yet, as Keath and Brown (2008) showed for the case of two Australian cities responding to extreme water scarcity, these crises can also act to further entrench traditional practices at the expense of emerging sustainability niches.

One could argue that the prospect of the dam, another technical water supply adaptation response, is reinforcing the existing governance regimes and is further disorienting the local perception of the actual value of the resource and the island's vulnerability to water stress. According to Interviewee 2 (2017), 'There is a shared belief that the Gadoura dam will solve all the issues of water stress. The people of the island expect that the dam will allow DEYAR to minimize the use of groundwater and let the aquifer to recover.' However, 'people's aspiration for the recovery of the groundwater is not really scientifically grounded since such an ecological process is rather complicated', as expressed by Interviewee 4 (2017). Our interviewees agreed that the dam has given to the locals the impression that it is the solution to continue with a business-as-usual approach. At the same time, none of the interviewed local authorities' shared such an optimistic perspective; they were more cautious when considering the impact of the dam on the island's water vulnerability as illustrated in the following quote. 'There is this false perception that the dam will cover the needs of the whole island. My opinion is that the dam could probably cover the needs of the 3/5 of the island, given that we will have enough precipitation.' (Interviewee 1, 2017). 'If we have a dam that we deplete every 1-2 years and for a year we do not have enough precipitation, what is it going to happen?' (Interviewee 2, 2017).

At this point, climate variability was an important factor of concern for the interviewees. Due to the traditional use of groundwater, which is less sensitive to climate variability, the Water-Tourism SES of Rhodes has not been much dependent on precipitation. The transition to the exploitation of surface runoff brings up new ecological dependencies and new dimensions of vulnerability, especially when considering that the islands of the Southern Aegean Region, located in the north-eastern Mediterranean region, are highly exposed and vulnerable to incidents of drought (Iglesias, Garrote, Flores, & Moneo, 2006). To obtain information specifically for Rhodes, we collected precipitation data for the period 1/1/1956 to 31/12/2016 and performed the Standardized Precipitation Index (SPI), a widely used index to characterize meteorological drought on a range of timescales. According to our results, since 1975 Rhodes is experiencing incidents of drought, which since 2000 have further increased in terms of frequency and intensity, forming a trend indicating change in the normal precipitation conditions. Referring to climate change, according to the projections and following an optimistic scenario (A1B IPCC scenario with fewer emissions and economic growth rate), the temperature of the South Aegean Region is

expected to increase for at least 1.5oC and the summer period will be extended for at least 10-15 days, while dry periods in Dodecanese are projected to increase for 10 days in the period 2021-2050. According to Becken and Hay (2007), increased stress from both tourism and climate change could eventually make certain destinations extremely water stressed, to the extent that further growth in their tourist industries will not be possible. These ecological trends and drivers of change to the Water-Tourism SES of Rhodes, in combination with growth in population, tourists, and water consumption (K/CH Ydatosustimaton Aigaiou, 2006), as well as tourism's changing spatiality on the island could make one wonder if 'a technical approach to water management in order to sustain the tourist industry may simply be postponing the inevitable outcome?' (Essex et al., 2004, pp. 24).

A second (probably less) possible evolution trajectory for the Water-Tourism SES of Rhodes unfolds, which demands more than the adaptation of the system, its transformation (Smit & Wandel, 2006). This could mean that a new balance will be achieved between the provision of tourism and the environmental capacities, in this case the water resources. As Essex et al. (2004) envision for the similar case of Mallorca, the tourism industry in Rhodes would face a period of substantial social and economic restructuring, induced by environmental drivers rather than commercial forces that usually determine such processes. According to Interviewee 2 (2017),

> 'The dam is not the solution. (…) We need to rethink our whole tourism industry. We may need to say that we have to bring less tourists, or even tourists of a different type. (…) It is in the human nature that only because of an urgent need established things may change. This is what I expect now to happen. It is the last two years that we witness for the first time on the island a huge discussion on the water issue and today we experience this crisis. I want to believe in such a change of attitude.'

> Interviewee 3 (2017) adds, 'I always believed that we should conduct a carrying capacity plan for the island. They never attempted to do so for different reasons, this is tricky especially in Greece. A carrying capacity plan would be a good input for any other planning attempt on the island, the water resources management included. I believe that only if there is an urgent need, only because of an evident need, they would do it. So now that we can see the water problem, maybe we will start thinking of this.'

Notwithstanding the ambivalent efficiency of the 'carrying capacity' concept and method mentioned by Interviewee 3, the interviewees expressed the need for a substantial adaptation of Rhodes' Water-Tourism SES that seems to connect primarily to a societal transformation through the prism of normative sustainability. Considering that the economy depends on healthy societies and ecosystems, normative sustainability criticizes the supremacy of markets and calls

for a view in which the economy is subordinated to social and ecological constraints (Becker et al., 1997; Parra & Moulaert, 2011; Parra, 2013). This connects to the consideration of alternatives to mainstream models of tourism development such as ecotourism, sustainable tourism, green tourism, slow tourism, community-based tourism, or even degrowth in tourism, which is considered to bring together all positive preconditions of other forms of low impact tourism that individual types of tourism do not (Andriotis, 2014). Hall (2015), viewing the impacts of tourism development on islands through island biogeographic theory, argues on the need for understanding sustainable island tourism from a steady-state economic perspective that explicitly recognizes the extent to which economic development is dependent on the stock of natural capital. A steady-state economy could be defined in terms of 'a constant flow of throughput at a sustainable (low) level, with population and capital stock free to adjust to whatever size can be maintained by the constant throughput that begins with depletion of low-entropy resources and ends with pollution by high-entropy wastes' (Daly, 2008, pp. 3). Thus, steady-state tourism is a tourism system that encourages qualitative development but not aggregate quantitative growth to the detriment of natural capital (Hall, 2015).

In the Rhodes Water-Tourism SES, the supremacy of markets is clearly reflected on its well-established mass tourism specialization and the absence of any strategy for a more sustainable approach to its tourism development (Interviewee 6 – Municipal Public Official for Tourism, 2017). Thus, the main challenge for a transformation to take place would probably be the escape from the well-established path-dependency (Wilson, 2014) (i.e. development adaptation pathway bounded by a 'corridor of the possible' beyond which certain human decision-making actions become 'unthinkable') of a tourism monoculture that continuously, artificially attempts to extend the environmental capacities that serve it.

CONCLUSION

In this paper, we identified the vulnerability to water stress of insular tourism destinations as a complex social-ecological phenomenon, and we followed a SESs approach to shed light on the diverse, multi-scalar social-ecological interactions that formulate it. We identified tourist flows, climate change, climate variability and supra-island governance as main drivers of change influencing the balance of an insular Water-Tourism SES, and we constructed an analytical framework for the investigation of the system's water-tourism complex and its underlying governance. This framework was applied to the analysis of the case study, the island of Rhodes in Greece, and revealed the island's emerging vulnerability to water stress, vulnerability trade-offs, spatiotemporal scalar mismatches of the social adaptations, and transformation prospects for the overall development trajectory of the SES. The semi-structured interviews method we used can be identified as an appropriate method for generating data that according to our knowledge cannot be found in any previous research for the island of Rhodes.

The approach we followed contributes to the general understanding of societal and environmental relationships and, more specifically, further extends the concept of SESs to include the less researched issues of water resources and tourism development. In addition, it contributes to the tourism literature by proposing an alternative understanding of sustainability and resources management in tourism. Relating to this, our work confirms the redundancy of the Malthusian view of a linear causal relationship between population growth and degradation of ecosystems (Hummel, 2012) and over-simplistic measures of tourism sustainability, such as carrying capacity. Rather, it stresses the importance to take into consideration contextual factors (e.g. tourism, climate variability and change) and intervening variables (e.g. local values, institutions governing resources) through multidisciplinary analyses that integrate in a dynamic way institutional, ecological and cultural components.

Furthermore, our analysis revealed a process we gradually expect to become manifest in many regions, which for their survival and development became increasingly dependent on the resilience of their social dynamics in contrast to their purely biophysical dynamics. The so far interventions that had been based on a short-term approach and reduced image of the dynamics involved (e.g. over-exploitation of groundwater) today seem to have accumulated and 'matured', resulting in the emergence of previously 'unseen' longer-term threats, which are now perceived as crises (e.g. Rhodes water crisis) (Young et al., 2006).

Finally, considering that in general terms, the insular Mediterranean makes sense as a unit of analysis due to common geographical attributes, established democratic systems, high levels of socio-economic development, and tourism dependence (Apostolopoulos & Gayle, 2002), the analysis and conclusions we offer could be valid for other Mediterranean islands as well.

CHAPTER 3

An ‘adaptation pathways’ approach: water resources management and governance in insular tourism regions

ABSTRACT

Approaches to decision-making for adaptation need to be place-centred and to consider the multiple interacting changes that occur at different spatiotemporal scales, climate and global change included. With its origins in climate change research, the ‘adaptation pathways’ construct, as a framework for iterative and adaptive decision-making processes fostering adaptations over time, provides an interesting input to this end. In this paper, we further elaborate on the ‘adaptation pathways’ considerations by framing them to the management and governance of water resources in insular tourism regions vulnerable to water stress. Considering tourists, climate variability and change, and supra-island governance as major interacting drivers of change having an impact on the balance of a Water-Tourism social-ecological system (SES), we seek to investigate the potential contribution of the ‘adaptation pathways’ framework in the building of adaptive Integrated Water Resources Management (IWRM) and governance approaches, which promote resilience to water stress and overall sustainable development for the SESs under consideration. To do this, we base our analysis on literature on climate change, water management and governance, water and tourism, and social-ecological systems. We illustrate our theoretical analysis with evidence from the islands of the Southern Aegean Region in Greece, based on secondary sources and complemented by data from interviews with stakeholders. Our analysis proposes an additional lens to frame adaptive and integrated water-related decision-making for Water-Tourism SESs, by bringing on board a more place-centred rather than water-centred perspective. It also offers the vision of using the (Southern Aegean) islands as laboratories for an experimental implementation of such an innovative approach in order to gain more insights on how to address water stress issues in insular tourism regions.

INTRODUCTION

Today societies are exposed to irreversible and out-of-control changes of increasing rapidity and complexity (Minteer & Pyne, 2015; Steffen et al., 2015). These are multiple socioeconomic and biophysical changes that occur at different spatiotemporal scales and influence the interrelated components of social-ecological systems (SESs), leading to diverse outcomes in different places (Bennett, Blythe, Tyler, Ban, 2016). The importance of considering multiple interacting changes has been acknowledged by many scholars and experts on vulnerability and resilience of SESs (Berkes, Colding, & Folke, 2003; Turner et al. 2003; Walker & Meyers, 2004), hazards and disasters (Berkes, 2007), and climate change vulnerability and adaptation (Adger 2006; Eriksen et al. 2011). To facilitate the analysis of vulnerability and adaptation to multiple interacting socioeconomic and biophysical changes in different places, Bennett et al. (2016) developed a conceptual framework and typology of drivers of change and exposures. This is an interesting contribution to further understanding and awareness of the entanglements of multiple interacting changes, which calls for a corresponding decision-oriented research to planning for adaptation. New approaches to decision-making are needed (Fazey et al., 2016), if planning is considered not only as a means to construct the (almost) unpredictable future but also as a means to navigate uncertainties and manage vulnerabilities and processes of adaptation to multiple interacting changes.

The climate change academic community has some time ago reacted to the growing intensity of calls for more decision-oriented research. However, adaptation research and practice focusing on climate change or global environmental change tend to neglect the incorporation of more place-specific attributes, changes and needs, often resulting in problem-centred - instead of place-centred contributions and risking potentially negative outcomes for one or more dimensions (Bennett et al., 2016; Butler et al., 2014). Only more recent attempts, framing adaptation within a ‘pathways’ metaphor, acknowledge that climate adaptation is part and result of the cultural, political, economic, environmental and developmental context in which it occurs. Reeder and Ranger (2011) originally introduced the ‘pathway’ metaphor to bring into focus the process of decision-making over climate change. A few years later, Wise et al. (2014) adopted a broader ‘adaptation pathways’ construct to include other forces of global to local change that may interact unpredictably, focusing on complex and dynamic multi-scalar SESs instead of on their individual components. We thus believe that the ‘adaptation pathways’ construct, as finetuned by Wise et al. (2014), is interesting and useful to examine more integrated decision-making processes and adaptation planning mechanisms that can enable SESs to better respond to multiple changes of their internal stresses and/or external

perturbations, as well as formulate sustainable futures. More specifically, we perceive the 'adaptation pathways' construct as part of the latest approaches to decision-making and planning which, underpinned by an adaptive rationale (Skrimizea, Haniotou, Parra, 2018), attempt to frame deliberative actions and desirable futures within the complexity of SESs. Furthermore, we understand the 'adaptation pathways' as a decision-making framework or approach with the potential to help scientists and decision-makers conceptualise adaptations to changes, through an iterative and adaptive decision-making process aiming at steering societies towards desired futures. To this end, Maru et al. (2014) developed a systems framework for exploring 'adaptation pathways' to climate change among people living in remote and marginalized regions. Butler et al. (2014) applied the 'adaptation pathways' to the analysis of rural livelihoods and global change in eastern Indonesian islands, and called for further framing and application of this approach to other cultural or socio-economic contexts.

In this paper, we further elaborate on the 'adaptation pathways" considerations by applying them to the analysis of the management and governance of water resources in insular tourism regions vulnerable to water stress. We do this by enhancing the existing scholarship on adaptations pathways and climate change with contributions on water management and governance, water and tourism, social-ecological systems, vulnerability and resilience, and island studies. We accompany and illustrate our theoretical analyses with evidence from the tourism islands of the Southern Aegean in Greece (Cyclades and Dodecanese) that are vulnerable to water stress, based on secondary sources and complemented by data from in-depth interviews with stakeholders.

Tourism increases the overall per capita water consumption and concentrates water demand in space and in time (Gössling et al., 2012). This, in combination with biophysical and geographical specificities such as insularity, environmental dynamics and governance choices, often makes many tourism destinations vulnerable to issues of water stress. Despite the significance of water in tourism development and the impacts of tourism in water resources, research on the topic remains limited and very recent (Hadjikakou, 2014). Considering tourists, climate variability and change, and supra-island governance as major interacting drivers of change having an impact on the balance of a Water-Tourism social-ecological system (SES), we seek to investigate the potential contribution of the 'adaptation pathways' framework in the building of adaptive Integrated Water Resources Management (IWRM) and governance approaches which promote resilience to water stress and overall sustainable development for the SESs under consideration. In this sense, the attempt of our paper matches and contributes to the paradigm shift in the field of water resources management and governance (Gleick, 2000; Pahl-Wostl, 2007; Schoeman, Allan, & Finlayson, 2014). As Pahl-Wostl (2008) summarizes, in contrast to the inflexible engineering water management regimes focusing on the management of the resource in order to optimize short-term efficiency, new IWRM approaches consider each 'water system' as a SES. These new approaches also put emphasis on socio-institutional

arrangements, and system level characteristics such as resilience and adaptive capacity. Since such novel answers to address water stress are still missing (Castro et al., 2018), our decision-oriented research work could be potentially helpful for enabling decision-makers in Water-Tourism SESs contexts. IWRM is a cross-sectoral policy approach that aims to promote the articulated development and management of water, land and related resources and avoid the traditional fragmented sectoral approach to water resources (Global Water Partnership, 2011). In this sense, IWRM encompasses water governance. In this paper, we will often make the distinction between water management and water governance. Water management will generally refer to the technical exercise of analyzing and monitoring, developing and implementing measures to keep the state of the resource within desirable bounds (Pahl-Wostl, 2008). Water governance will refer to 'the range of political, social, economic and administrative systems that are in place to regulate development and management of water resources and provisions of water services at different levels of society' (Global Water Partnership, 2002 cited in Rogers & Hall, 2003).

Our empirical contribution focuses on the islands of the Southern Aegean in Greece and is based on the analysis of secondary sources and in-depth interviews with stakeholders, carried out between March and August 2017 in Athens and Rhodes. The Southern Aegean Region is constituted by small islands, many of which are popular tourism destinations in Greece and internationally. This region is characterized as 'water deficient' (Koutsogiannis et al., 2008). The intensity of the water problem in the islands correlates with the development and intensity of tourism, which is considered to be the most critical parameter affecting their water availability. Most of the studies on the issue of water security in the Southern Aegean islands originate from water managers performing technical, quantitative assessments. By considering water security as a mere problem of consumption that can be solved with 'new' engineering solutions to meet water demand, these technical assessments overlook crucial advances in the water resources management field (e.g. Kaldellis & Kondili, 2007). Similarly, in practice, the islands are ruled by inflexible engineering water management regimes that are inadequate to address contemporary challenges and to manage the islands' vulnerability to water stress. Bearing this in mind, we highlight the academic interest and social relevance of discussing the challenges of the water stress and adaptation faced by these islands through an 'adaptation pathways' approach.

The paper is structured as follows. First, we briefly review the 'adaptation pathways' construct and demonstrate its relevance to the paradigm shift in the fields of water resources management and governance. Second, following a SES perspective, we define the Water-Tourism SESs and analyze the main interactions leading to vulnerability to water stress. Then, using examples from the Southern Aegean Region islands, we explore how the critical aspects of adaptation that the 'adaptation pathways' aim to address manifest in the water management and governance challenges faced by Water-Tourism SESs. In the discussion section,

we envision the Southern Aegean islands as laboratories for the development of ‘adaptation pathways’ approaches. We explain the need for such a transformation of the islands’ water management and governance regimes and we question the way this transformation could be generated. The last section provides brief concluding remarks along with further implementation prospects of the ‘adaptation pathways’ for Water-Tourism SESs.

‘ADAPTATION PATHWAYS’ AND COMPLEX WATER ISSUES

Adaptation, when referring to human subsystems (household, group, sector, region, country) of a SES, refers to a process, action or outcome that aims to enhance resilience to change, i.e. better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity (Smit & Wandel, 2006). According to the degree of adjustment or change required, there can be many levels of adaptation, and thus the concept of (human) adaptation includes the possibility of more extensive transformations. Transformations imply ‘fundamental changes to underlying political and economic structures, shifts in perception and meaning, changes in underlying norms and values, reconfiguration of social networks and patterns of interaction, changes in power structures, and the introduction of new institutional arrangements and regulatory frameworks’ (IPCC, 2012, pp. 465).

‘adaptation pathways’ view adaptation as occurring over time, where key decision and intervention points are identified to help navigate and influence the direction of change (Figure 1). Thus, in the ‘adaptation pathways’, each decision and societal intervening action is not an external element of control, trying to impose a (dys)functional and (un)natural order in an otherwise spontaneous and complex social-ecological process. Instead, decisions and societal intervening actions take part in the social-ecological complexity as integral elements within its dynamics, adapting to but also influencing the SES’ evolutions (Boonstra & Boelens, 2011). In addition, in an ‘adaptation pathways’ approach the focus is more on the process of decision-making, rather than the outcome (Wise et al., 2014). Thus, without claiming that the process is an end in itself, the concept of pathways does not focus on maximizing the planning result in line with some predefined goals but in optimizing the planning process according to the changing needs along open trajectories (De Roo, 2007; Hillier, 2010).

Originally, pathways approaches focused on the uncertainty in knowledge required to develop a sequence of actions that produce desirable events, based on the premise of unambiguous goals and centralized decision-making (Fazey et al., 2016). This kind of uncertainty is certainly a challenge considering that adaptations are nested within complex and evolving SESs. In this sense, adaptations usually embed both opportunities and threats, which may bring-up vulnerability and resilience trade-offs leading to unpredictable, unwanted or unsustainable development trajectories (Lauer et al., 2012). However, adaptation problems are often even more complex than this, involving multiple distributed decision-makers across scales, who have unequal power, competing values, goals and knowledge. It then becomes clear that each decision in each intervention point is much more than a technical and scientific exercise seeking knowledge and certainty. For this reason, Wise et al. (2014) broadened the pathways approach to foster an iterative and adaptive governance process for designing and implementing collective action. In this case, the multiple sustainable

pathways imply also the diverse political and ethical choices that will define what should be considered as a 'desirable adaptation' and what as an 'acceptable trade-off'.

The aforementioned adaptive and integrated way in which the 'adaptation pathways' construct conceptualizes decision-making for complex issues coincides with the needs and goals of contemporary water resources management and governance. In the 'Urban Water Management Transitions Framework', Daniell, Rinaudo, Chan, Nauges, and Grafton (2015), describe the evolution in the goals of the urban water management field initiating from the 'Water Supply City' to today's 'Adaptive and Sustainable Urban-Rural System'. The 'Adaptive and Sustainable Urban-Rural System' encompasses the demand for a transition to new, adaptive and integrated approaches. More in detail, water management has traditionally been characterized by a command-and-control paradigm and by the dominance of large-scale technology, expert knowledge, technical and engineering solutions (Pahl-Wostl, 2009). This early group of practices has served well in the past to provide technical responses to problems, such as the construction of infrastructure to ensure water supply. However, it has become clear that the contemporary complex water issues with deep uncertainty and depending on highly political decisions demand different kinds of approaches (Haasnoot et al., 2012): the increasing water demand; the interconnectedness of increasingly competitive water functions and stakeholders; the multiplication of power scales at which water-related decision-making is exercised; and the deeper understanding of the water risks induced by global change, have all led to the recognition of the modern water issues as complex and pluralistic. These complex water issues are acknowledged to demand approaches that are more integrated, accompany technical solutions with an understanding of SESs adaptation dynamics, and incorporate proper and fair (water) governance (Brugge & Rotmans, 2007; Pahl-Wostl, 2009).

In accordance with the 'adaptation pathways' premises, the IWRM approaches consider each 'water system' as a SES and rather than focusing on the management of the resource in order to optimize short-term efficiency (i.e. single adaptation choices as points in time), they put emphasis on system-level characteristics, such as resilience and adaptive capacity, aiming in a long-term sustainability (i.e. adaptation as a pathway and process through time) (Pahl-Wostl, 2008; Schoeman, Allan, & Finlayson, 2014). The 'integrated' in IWRM also indicates the need for management measures across different sectors and spatiotemporal scales, as well as processes of consultation and stakeholder participation, recognizing the importance of water in the overall territorial development (Brugge & Rotmans, 2007). Adaptive management, on the other hand, is used here in a slightly different way than it is used in environmental management. In environmental management, adaptive management refers to 'experiments' for testing hypotheses about system behaviour. In water resources management, it refers to a systematic process of improving management policies and practices by learning from the outcomes of implemented strategies, as well

as from the new conditions brought up by the evolution of the SES under consideration (Pahl-Wostl, 2008). The overall aim of this adaptive process is to increase the adaptive capacity of the SES and enhance its ability to move across pathways by putting in place learning processes, which we could say that refer to the intervening iterative points of the 'adaptation pathways' construct.

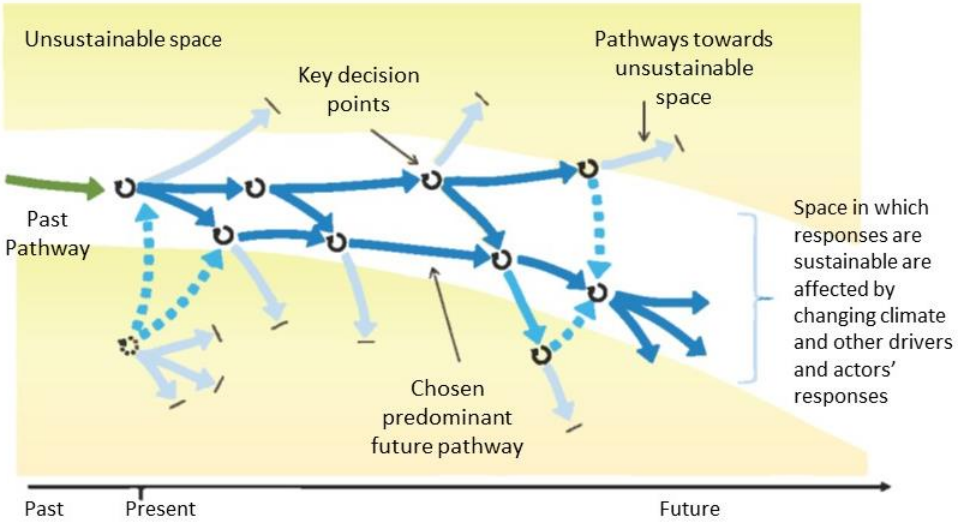

Figure 1 - 'adaptation pathways' that conceptualize the emergence of future routes for adaptation. Dark arrows represent different possible routes that could be taken, circle arrows represent decision points, lighter arrows lead to maladaptive dead-ends, and dashed arrows represent more-or-less transformative pathway segments. Arrows to the left (before present) represent historical pathways. The unshaded background space represents the context in which in which responses to change and adaptation are considered socially and environmentally sustainable. The boundary of this space also changes, such as the result of changes in climate or other conditions. Source: Fazey et al., 2016

Considering the above, the 'adaptation pathways' construct is a relevant input to the contemporary water resources management and governance since the respective fields of study seem to share premises, goals, concepts and approaches. Nevertheless, to investigate further the implications of an 'adaptation pathways' approach to water resources management and governance, a more place-specific and context-sensitive consideration is needed. In the following sections, we focus on the Water-Tourism SESs to analyse the interactions that contribute to vulnerability to water stress, discuss the concomitant challenges, and justify the need for an 'adaptation pathways' approach.

WATER-TOURISM SESs AND THEIR VULNERABILITY TO WATER STRESS

Central to the 'adaptation pathways' construct is the definition of complex SESs. An island, hosting clearly delimited terrestrial ecosystems including human presence, can be perceived as a naturally bounded SES yet porous, open to both positive events and threats (Jackson, 2008). As such, the island-SES in this paper includes (i) aquifers, the related watershed and hydrological processes that determine the amount of water available on it; (ii) the relevant social counterparts including a diversity of users, infrastructure, governance systems, and cultural attributes, and; (iii) its socio-ecological path-dependencies and path breakings (see also Cole & Browne, 2015).

For the purpose of our analysis, the Water-Tourism SES refers to the destination without the tourists, whom we consider to be temporally 'exported' drivers of change, originating from the external to the SES environment. Here, the concept of 'tourists' refers not only to tourists as 'visitors' that add on the number of the permanent population but to the entire chain of (water) consumption that is mobilized when a tourist arrives at the destination. Because of the tourists' flows, tourism creates ephemeral localities of extremely high population density, heterogeneous water users, and high water demand (Essex et al., 2004; Gossling et al., 2012, Hadjikakou, 2014). Other relevant drivers of change of particular interest to our Water-Tourism SES are climate variability and change. For many destinations, peak demand occurs in dry seasons, characterized by limited precipitation, warm climate, and restricted water availability. This can imply inverse relationships between water availability and water use (Gossling et al., 2015), especially on islands due to their often-immediate dependence on precipitation and the practical difficulties included in the use of transboundary water to compensate for water shortages. In addition, considering longer-term time horizons, climate change may alter the demand for water and the ability to distribute water to meet customers' needs, particularly at times of peak demand, since it is especially the peak domestic demand that is very sensitive to climate change (Arnel & Delaney, 2006). As an additional driver of change, we identify the supra-island governance influencing the local governance of the Water-Tourism SES. This driver of change may be less relevant in the case that the island is a country (e.g. Cyprus) but it can be an important parameter for islands that constitute parts of countries' territories (e.g. the island of Rhodes). The supra-island governance as a driver of change refers to the dependence of the Water-Tourism SES governance on the regional administrative level and/or the dependence of the Water-Tourism SES governance on the national level, according to the way water governance is arranged and practiced in each country. Moreover, supra-island governance may refer also to institutional and governance influences originating beyond the national level such as the EU Water

Framework Directive.

Summarizing, we identify four main drivers of change affecting the balance of our Water-Tourism SES: (1) Tourists; (2) Climate variability; (3) Climate change; (4) Supra-island governance. Climate variability and climate change influence directly the resource, tourists influence directly the users-group identity and behaviour, while supra-island governance influences the (water) governance on the island[24]. Water stress could be then perceived as a possible outcome[25] resulting from the whole of the interactions that formulate the vulnerability of a SES. In accordance with the latest premises and findings of vulnerability research (Adger, 2006; Turner et al., 2003), vulnerability should be positioned within the 'action situation' of the SES (Ostrom, 2007; 2009), being formed by both the social and ecological subsystems and the SES' context. Considering vulnerability as the result of the interaction among exposure, sensitivity and resilience (Adger, 2006; Turner et al. 2003), the human subsystem deals with the drivers of change through a set of adaptive capacities and actual adaptations (Chelleri, Minucci, & Skrimizea, 2016). These responses-whether autonomous or planned, public or private, individual or institutional, tactical or strategic, short-term or long-term, anticipatory or reactive-can have mitigating or amplifying effects to vulnerability for the different spatiotemporal scales of the SES. Thus, the adaptive responses will also collectively determine the vulnerability (and resilience) of the SES (and for parts of the SES) and may transcend the system of analysis, affecting other spatiotemporal scalar dimensions of the phenomenon with potential feedback on the Water-Tourism SES in question (Turner et al., 2003). In this context, the vulnerability to water stress has to be considered in its interaction with resilience as 'a set of related antagonisms' at different spatiotemporal scales (Propeck-Zimmermann, Saint-Gérand, Haniotou, & Skrimizea, 2018).

The above considerations move beyond the usual analyses of water stress in tourism destinations as simple problems of increased water consumption leading to the depletion of the resource. Besides, current literature has revealed that such direct causal explanations oversimplify complex realities and are of little instructive value (Hummel, 2012). According to our analysis, the role of the SES governance would be to inevitably negotiate vulnerability and resilience trade-offs (Lauer et al., 2013) in order to frame for the Water-Tourism SES sustainable

[24] It is evident that the reality is far more complex. For instance, climate change may influence the tourist flows and thus indirectly the users, the supra-island governance may also influence the tourist flows and indirectly the users, the tourists from their side certainly influence the governance choices etc. The Water-Tourism SES we propose constitutes a first step towards a SES approach to the water-tourism complex that we consider sufficient for the needs of this paper. It does not intent to be exhaustive and is subject to future research.

[25] Here, our reference to vulnerability as an 'outcome' should not be confused with the climate change scientific community's initial conceptualization of vulnerability as an outcome – an outcome that can be quantified and measured, and reduced through technical and sectoral adaptation measures. Instead, as it is evident from our analysis, we include in our definition of vulnerability the 'contextual' understanding of the concept according to which vulnerability is considered to be influenced not only by changing biophysical conditions, but by dynamic social, economic, political, institutional and technological structures and processes as well; i.e. contextual conditions (O' Brien, Eriksen, Nygaard & Schjolden, 2007).

and flexible long-term development 'adaptation pathways' linked to dynamic changes over time. Hence, an understanding of the vulnerability to water stress such as the above makes clear that a traditional command-and-control technical approach to water resources management and governance would not be enough. However, recent research emphasizes that solutions to address water stress associated with cross-scale and cross-sectoral SES interdependencies have not yet been broadly implemented (Castro et al., 2018). In other words, the advances in the sciences of water considering the development of integrated and adaptive solutions are often not reflected on the ground. Especially when it comes to issues of water stress, the scientific knowledge on the drivers of change and social-ecological dynamics that shape the phenomenon rarely guides practice (Ibid.). This mismatch between theory and practice is evident in the islands of the Southern Aegean Region in Greece, where still the dominant response to water stress is the quest for additional supply through technical solutions within an anachronistic engineering water management regime. Thus, it is interesting to discuss the water stress and adaptation challenges of these islands through an 'adaptation pathways' lens, as we do in the following section.

CRITICAL DIMENSIONS OF THE ADAPTATION CHALLENGE IN THE WATER-TOURISM SESs IN THE SOUTHERN AEGEAN, GREECE

Conceptualizing adaptations using the pathways construct, rather than as individual decisions and actions, permits to embed the 'adaptation challenge' within the overall social-ecological 'development challenge' of a place. According to Wise et al. (2014), this results in conceptualising adaptation through five critical dimensions that have been under-represented in the literature so far. First, society should not consider climate change in isolation from other forces of global to local change. Second, adaptations often present cross-scale and cross-sector effects and they thus need to be coordinated to avoid maladaptation (Barnett & O'Neill, 2010). Third, due to positive feedback loops, system trajectories (or pathways) are path-dependent, often 'locked-in' and difficult to change challenging the adaptations' applicability and efficiency. Fourth, it is difficult to determine the current trajectory of the SES and its position within an 'adaptation pathways' roadmap, as a fundamental step towards identifying the adaptation that might be needed. Fifth, adaptations are enabled or constrained by prevailing rules, values and knowledge cultures, and their interdependencies. For the needs of this paper, we have reworked and fine-tuned these dimensions to the ways in which they manifest as challenges in the water-related adaptation processes of Water-Tourism SESs. We illustrate this analysis with examples from the Southern Aegean Region islands in Greece.

CONTEXT AND METHODS

The southern Aegean Region includes the Cyclades and the Dodecanese islands (Figure 2) and, according to the Hellenic National Programme of Management and Protection of the Water Resources, it constitutes part of Greece's 14th River Basin District[26] (Koutsogiannis et al., 2008). The total area of the Region is 5,286 km^2 (4% of Greece) (Kaldellis & Kondili, 2007) and includes 52 inhabited islands and 226 uninhabited islets. According to the latest census, the Region's population is 309,015 inhabitants with a growth rate of 3.5% between 2001 and 2011 (EL.STAT., 2011a). The area under study constitutes the most important insular complex of the country by the number of its inhabited islands, many of which are popular tourism destinations in Greece and internationally, with a

[26] The Greek National Programme of Management and Protection of the Water Resources in the framework of the Water Framework Directive divides Greece into 14 River Basin Districts. The 14th River Basin District covers all the islands of the Aegean and challenges the implementation of the Directive due to its spatial discontinuity.

great contribution to the country's GDP (Haniotou & Klabatsea, 2014). The Region's GDP per capita has developed in parallel with tourism's development from 15,501€ in 2002 to 20,986€ in 2007 (EL.STAT., 2010), following a larger growth rate than the national average (Kaldellis & Kondili, 2007). However, the Southern Aegean Region is also characterized as 'water deficient' (Koutsogiannis et al., 2008) and along with Attica Region, it is considered to be the most vulnerable Region to the risk of water scarcity in Greece (Estrela, Marcuello, & Iglesias, 1996; Karagiannis & Soldatos, 2007). More specifically, the southern Aegean islands in Greece have limited water resources, both due to the climatic conditions and their geophysical specificities. These limits were exceeded long ago, mainly due to the seasonal mass tourism monoculture and a problematic water management and governance regime leading to over-exploitation of resources. On top of that, current climate conditions, climate trends and climate change projections indicate an increasing demand in water needs and a decrease in its availability. Under these conditions, the islands under review are already facing important water imbalances that are projected to increase in the near future (Iglesias, Garrote, Flores, & Moneo, 2006; Zerefos et al., 2011).

The analysis that follows is based on data collected from policy documentations, scientific literature, local press, and other reports, and is being complemented by results from in-depth interviews with stakeholders, carried out between March and August 2017 in Athens and Rhodes (for details on the methodology followed see paper 2 in this thesis). The interview data presented in this paper was part of a larger project investigating the vulnerability to water stress in insular tourism regions and refer mainly to the island of Rhodes. Thus, in the following sections, Rhodes will be sometimes used as a more specific example in order to provide a more in-depth understanding of certain local social-ecological dynamics and adaptation challenges throughout the analysis. Rhodes constitutes an average case and representative example of the way water is managed in Greece. Rhodes, which is part of the Dodecanese islands, is a major tourism destination in Greece and within the Mediterranean, being a success story of mass tourism since the 1960s. It was considered an island rich in water resources that, however, in the last few years, faces evident issues of water stress. This situation, in the summer of 2017, resulted in a big local water crisis. The intensity of the water problem in Rhodes correlates with the development and intensity of tourism as it happens to most of the Southern Aegean islands.

Figure 2 - Cyclades and Dodecanese: The islands of the Southern Aegean Region. Source: Google Earth, Adapted by E. Skrimizea Authors

DIMENSION 1: MULTIPLE INTERACTING CHANGES

The Tourism-Water SES analysis we provided earlier make rather clear that climate is only one of the diverse natural or human-induced factors that directly or indirectly may contribute to water stress in a Water-Tourism SES. Thus, in order for climate adaptation to be effective, it should indeed be considered in combination with other drivers of change and adaptation responses from different scales and sectors, in accordance with the first of the five critical dimensions of the adaptation challenge.

The Southern Aegean Region constitutes a good example of how multiple drivers of change may contribute to water stress. In the Southern Aegean Region, tourism is a major driver of change that influences both directly and indirectly the water availability. The increase in permanent population, the dramatic increase in population during the summer months[27], the increase of per capita water consumption, and the extension of water uses (swimming pools, landscape irrigation, gardens, golf courses etc.) have all created a constantly growing, unevenly distributed in space and time, water demand (Zerefos et al., 2011; Zotalis, Dianlynas, Mamassis, Angelakis, 2014). Then, there is climate variability. The islands of the Southern Aegean Region, located in the North-eastern Mediterranean region, are highly exposed and vulnerable to incidents of drought. During the frequent drought periods, the water stress problems are intensified and become easily evident due to many islands' immediate dependence on precipitation and the practical difficulties included in the use of transboundary water to compensate for water shortage (Lange et al., 2006). Moreover, according to climate change projections, the already hot and semi-arid climate of southern Europe is expected to become warmer and drier, with more heat waves and periods of drought[28] (Lange et al., 2006; Zerefos et al., 2011). Under all climate change scenarios in the Mediterranean region, available water resources decrease, while water demand increases (Iglesias et al., 2006). Finally, although each island's water service is under the supervision of the respective municipal organization (DEYA - Water Supply and Sewerage Company), the supra-island water governance is another relevant driver of change that challenges the SES evolution. For instance, in Rhodes the decision for the construction of the Gadoura dam, which is the biggest in the Aegean both in terms of the size of its embankment and the volume of annual runoff and capacity (Mihas, Oikonomidis & Tsialas, 2008), was taken at the National and Regional administrative levels. The Regional authorities were also responsible for the construction of the dam, while the municipality and DEYAR are responsible for its maintenance and the necessary infrastructure for the distribution of water. The challenge in such cases is to make sure that the supra-island adaptation strategies are in line with the local adaptations, evolutions and needs. In the case of Rhodes, analysis has revealed the supra-island governance as an important driver of change that in its interaction with the local water governance resulted in adaptations' spatiotemporal scalar mismatches that amplify the island's vulnerability to water stress (see paper 2 in this thesis). This last consideration for Rhodes connects directly to the following critical dimension emphasizing the threat of maladaptation.

[27] The seasonality of the tourism demand in some cases means a temporary summer population ten or even thirty times over the winter population (Gikas & Angelakis, 2009; Haniotou & Klabatsea, 2014).

[28] The HadCM3 model for the A1F IPCC scenario gives a dramatic increase of 66% in future drought occurrences (Tigkas, 2008). For a more optimistic scenario (A1B IPCC scenario with fewer emissions and economic growth rate), according to the projections, the dry periods are projected to increase for 20 days in the Cyclades and 10 in the Dodecanese the period 2021-2050 (Zerefos et al., 2011).

DIMENSION 2: THE QUEST FOR 'POSITIVE' OR 'SUSTAINABLE' ADAPTATIONS

Viewing adaptation as a process embedded in the context of multiple interacting changes and undertaken by individuals, groups or governments with possibly different objectives implies that adaptation is not neutral, as it happens also with other complexity sciences' concepts when these expand the scope of their concerns from the natural sciences to the social-ecological sphere (see for instance Matin, Forrester, and Ensor, 2018). In fact, as already mentioned above, adaptations to multiple drivers of change encompass opportunities and threats and may bring up trade-offs, diminishing the exposure to some hazards but indirectly increasing the exposure to others, or bringing up new ones in the long run (Lauer et al. 2013). Sanders (2008) acknowledges the neutral nature of adaptation and questions the 'positive' interactions that could lead to 'positive' emergent patterns and overall 'positive' adaptation of a system. To this end, Eriksen et al. (2011, pp. 2) argued for the importance to integrate adaptation research and practice with sustainable development, defining sustainable adaptations as 'adaptation that contributes to socially and environmentally sustainable pathways, including both social justice and environmental integrity'. The recent global economic crisis, as an additional global driver of change that has deeply affected Greece, has called for adaptation strategies with important effects on the vulnerability of the Southern Aegean islands to environmental pressures, in general, and water stress, in particular. Tourism is traditionally one of the most important contributors in Greece's GDP and during the economic recession, it proved to be one of the most resilient sectors of the Greek economy[29] (Psycharis, Kallioras, & Pantazis, 2014). Thus, nowadays, the islands' mass tourism is considered to be one of Greece's main strategic tools for rapid economic growth, making environmental protection seem less crucial (McKinsey & Co., 2012). The first two memoranda[30] aimed, among others, to looser environmental legislation concerning the development of touristic infrastructure in order to promote a pro-growth planning with fast-track investments, regardless carrying capacity limits and without proper policies to accompany the pressure on water and other resources (Giannakourou & Kafkalas, 2014). Greece's new growth model, as an adaptation to global economic changes, challenges the diachronically sensitive balance between environment and development (Lekakis & Kousis, 2013), increasing the exposure of the islands to hazards relating to an unsustainable tourism growth, water stress included.

At the local level, in Rhodes, a water crisis in the summer of 2017 revealed the unsustainability of the island's traditional adaptation practices to the growth in water demand. More specifically, Rhodes' local policy responses to the increasing

[29] In 2009, the Southern Aegean Region was the Region with the highest GDP per capita (25,290€ when the national average was 20,830€) (EL.STAT., 2011b).
[30] The first Memorandum, centred on internal devaluation and a series of taxes and accompanying the first Greek bailout programme, was incorporated in Law 3845 in May 2010. The second Memorandum, including additional austerity and liberalisation measures and accompanied by the second bailout agreement, was incorporated in Law 4046 in February 2012 (Markantonatou, 2013).

water demand have been referring to the reactive construction of new boreholes, in the absence of an overall plan and monitoring of the water situation. This kind of responses or 'coping strategies' (Smit & Wandel, 2006) might have temporarily reduced the system's sensitivity to water stress yet increased its overall vulnerability in the longer term. Thus, although Rhodes used to be, according to the interviewees, an island rich in water resources, in the last few years it faces evident issues of water stress that have revealed the need to integrate adaptation with long-term planning and overall territorial (sustainable) development (see paper 2 in this thesis).

DIMENSION 3: THE CHALLENGE OF PATH-DEPENDENCY

The 'adaptation pathways' construct recognizes the importance of historical determinism and path-dependency in the shaping of future trajectories and calls users to consider their implications for adaptation planning (Wise et al., 2014). As Wilson (2013) argues, path-dependency refers to the adaptation pathway being bounded by a 'corridor of the possible' beyond which certain human decision-making actions become 'unthinkable'. Alternatively stated, initial conditions form political, institutional, economic, cultural and other legacies that filter decision-making options. It is in this case that a SES can find itself in a lock-in situation, which has to be recognized by the relevant stakeholders as in this case a transformation might be necessary to avoid maladaptation.

The challenge of path-dependency and the relating lock-in effects is rather evident in the case of Tourism-based SESs and especially in the case of tourism islands. Islands may vary in almost every aspect: geographical, ecological, political, social, and economic (Apostolopoulos & Gayle, 2002). Nevertheless, academic literature does seem to agree on some common development patterns undergone by islands, which are articulated in what we could call the 'insularity and islandness model'. Islands are commonly associated with conditions of smallness, remoteness, isolation, discontinuity, peripherality, vulnerability and dependency, summarized in a concept of insularity, which is used broadly to describe their geographic situation and their ecological, social and economic sensitivities (Christofakis et al., 2009; Coccossis, 2000; Benedictis & Pinna, 2015; Douglas, 2006). At the same time, these insularity features have been proven to be valuable 'resources' for islands and a key a comparative advantage for tourism through a stock of natural capital (Armstrong & Read, 2006; Sufrauj, 2010). In this case, the concept of islandness confers a positive connotation to the same attributes of insularity (Jackson, 2008; Sufrauj, 2010). As Conlin & Baum (1995, pp. 4) mention, 'the allure of islands, be they in the Mediterranean, the Atlantic or the Pacific, as places where people go for relaxation and rejuvenation, has a long tradition which continues unabated'. The insularity and islandness model as

described above illustrates that islands are places that due to certain geographical attributes present inherent structural lock-in effects linked to constraints and opportunities for economic development (Wilson, 2013). These structural lock-in effects often later result in economic lock-in effects in the form of tourism monoculture, which largely affects the adaptive capacity, limits the adaptation options, and increases vulnerability to maladaptive outcomes due to 'monofunctionality' and over-reliance on the environmental capital (Ibid.).

The above development pattern is evident in most of the Southern Aegean islands. In these islands, for years, the basic source of income was agriculture (Kizos, Spilanis, & Mehmood, 2009). The first attempts in developing the tourism industry were made during the 1950s. Gradually, the local communities embraced the idea of a higher 'economic return more easily and in less time' compared to agricultural production (Haniotou & Klabatsea, 2014: 38). This transition phase, from an agricultural economy to a tourism-based economy was clearly identified at the beginning of the 1970s but has gradually been consolidated in the subsequent years (Tsartas, 2003). Finally, today, tourism is the only economically dynamic activity for the majority of the islands and the intensity and duration of tourism development are positively related to their population and economic growth (Spilanis & Vayanni, 2003). However, the development of the mass tourism model and the unrestrictive exploitation of the attractiveness of the islands inevitably jeopardized the sustainability of local, cultural and natural, resources (Tsartas, 2003). The result is that many islands face severe pressure from the construction of large-scale infrastructure, the urbanization and congestion resulting from increased tourist numbers and high demands in energy and water consumption (Kizos et al., 2009). Despite the scientific debates on the sustainable development of tourism in these islands and the emerging vulnerabilities due to accumulated overexploitation of resources, the economic success of the current development pattern, the subsequent political power of the tourism sector, and the diachronic abandonment of other options seem to limit the islands in their capacity to follow more sustainable 'adaptation pathways'.

DIMENSION 4: SYSTEM STATE AND THRESHOLDS IDENTIFICATION

The identification of the Water-Tourism SES' location within the adaptive space of the 'adaptation pathways' is a challenging but important task. The misdiagnosis of the location of the system could result in failing to identify its proximity to thresholds and may ultimately lead to maladaptation (Wise et al., 2014). For instance, in the case of a Water-Tourism SES, the identification of the SES' location within the adaptive space could profit from the rough detection of tipping points for the water resource subsystem (Walker & Meyers, 2004). Considering however that such thresholds are difficult to determine and as a task

it mostly remains within the realm of scientific research (Renaud, Birkmann, Damm, & Gallopın, 2010), this is a practice that presupposes an integration of multiple types of knowledge, and a dialectic relationship between scientists and policy-makers for evidence based decisions.

In the Southern Aegean islands, the proper monitoring of the water resources' evolution, in combination with the proper monitoring of tourism's evolution in space and time, could provide certain social-ecological thresholds. However, both our desk research and fieldwork revealed the lack of monitoring of the water resources situation in Greece and especially the lack of data about water demand/consumption and availability. For instance, to calculate demand and consumption, policy documentation, scientific publications and other reports usually use approximations based on the international literature (permanent population 150-200lt/person/day, tourists 300lt/person/day) rather than real water demand and consumption rates (Koutsogiannis et al., 2008). Furthermore, in Rhodes, island showing in the last years a depletion trend of its groundwater reserves, a public official mentioned (Interviewee 1, 2017 - Municipal Public Official for Energy and Industry),

> 'The problem is that all these years we have been conducting groundwater abstraction in the absence of any monitoring mechanism. The boreholes, they are not all the same and there are ways to 'learn' each of them. I mean that the groundwater resource's availability in conjunction with the rhythm of depletion and replenishment could provide certain thresholds decision-makers could work with in order to avoid salinization or over-abstraction and respect the ecological limits. However, the boreholes are not being monitored in a scientific way. We do not have the people or the will to do it.'

What is more, a technician from the Rhodes Water Supply and Sewerage Company (Interviewee 2, 2017) commented 'I do not really have any tangible data to give you. We have everything here (showing his brain)' and he continued 'our technicians in the different villages of the island know well those places and work according to their empirical knowledge'. Although empirical knowledge is of course a valid type of knowledge, this is certainly not enough. The situation in Rhodes reflects the overall situation in the islands and mainland of Greece. Long-term water planning that could favour scientific input and monitoring practices has never been a priority. Instead, more short-term and uncoordinated practices have been developed (Koutsogiannis et al., 2008). Short-term uncoordinated practices can be found also in tourism development and regional planning, which refer to and influence the water demand side. In the words of Interviewee 3 - Regional Public Official for Spatial Development,

> 'We are thinking in very short time scales without any vision. (…) Can Rhodes accept, from a social and environmental point of view, the construction of new hotel infrastructure? In my opinion, the island's

> carrying capacity has been exceeded. However, how can we prove this? Many times in different regional meetings, we provide positive feedback for the further tourism development of the island because we do not have any data that could help us argue questioning the sustainability of the approach followed. I am sure that what I tell you is right but I also have to prove it and we do not have neither the proper data nor the scientific support to do so'

This incapacity of the Greek public authorities to take evidence-based decisions for the water management in the Southern Aegean islands is directly connected to the role of prevailing rules, values and knowledge, as analysed below.

DIMENSION 5: THE ROLE OF PREVAILING RULES, VALUES AND KNOWLEDGE CULTURES

The majority of adaptation efforts in literature and practice have been conceptualised as problem-oriented incremental actions to proximate causes of vulnerability, i.e. small changes to existing practices in order to sustain what is considered as 'normal' functioning of a SES (Termeer, Dewulf & Biesbroek, 2017). Such adaptation actions, which are usually local and short-term, often turn out to be maladaptive because effects of long-term change are marginalised while the interactions between decision lifetimes, the uncertainties about the nature of biophysical change and the range of possible adaptation options tend to be downplayed (Collof et al., 2017; Stafford Smith, Horrocks, Harvey, & Hamilton, 2011). Especially in the case that the system is not currently located in the adaptive space, then any of the possible incremental actions may lead to maladaptive pathways (Wise et al., 2014). The aforementioned recognised limits of incremental adaptation have fuelled the scientific debates on transformational change as a much needed complement to the incremental steps that the adaptation community has discussed thus far (Kates, Travis, & Wilbanks, 2012; Termeer, Dewulf, & Biesbroek, 2017; Wise et al., 2014). Thus, if we agree that adaptation in an 'adaptation pathways' approach is analytically framed through the five 'critical dimensions', we recognize particularly the contribution of this 5th dimension, on rules, values and knowledge cultures. We do so because, according to the definition of transformation provided earlier in this paper, the consideration of the role of the prevailing rules, values and knowledge cultures in generating adaptive capacity and addressing vulnerability permits a certain conceptualisation of adaptation, which favours adaptation responses that are transformational in nature (Collof et al., 2017; Wise et al., 2014).

The Southern Aegean islands find themselves within another path-dependency that refers to the diachronically disabling role of the prevailing rules, values and knowledge cultures in developing sustainable adaptations to water stress. More specifically, the issue of water stress in the islands is generally being perceived as

a simple function between the amount of demand and this of supply and thus as a quest to increase water supply according to the increased demand in order to 'serve' tourism development. Hence, the islands have found themselves in a locked-in situation of covering an increasing water demand by increasing water supply through certain (incremental) adaptations (e.g. expansion of the boreholes network, water transfers from the mainland, construction of big engineering projects desalination plants) (Gikas & Angelakis, 2009; Kaldellis & Kondili, 2007; Sauter et al., 2013; Zotalis et al., 2014). First, the over-emphasis on water supply management often leads to over-exploitation of the resource and underestimation of its value by its users and, consequently, calls into question the overall long-term sustainability of a region's development (Brown, Keath, & Wong, 2009). For instance, according to the data from the General Secretary of Aegean and Island Policies (2010), the amount of water that is transferred to Southern Aegean Region's islands every summer has a growing tendency, co-evolving with an increase in demand and consumption. Then, although such adaptations are not by definition ineffective or unsustainable, the fact that they are being developed in the absence of an integrated, adaptive, long-term, evidence-based approach to water resources management and governance often leads to maladaptation as it happened in the case of Rhodes (see paper 2 in this thesis). This recurrence of water practices that, in the form of incremental adaptations, ignore the advances in the fields of water management and governance and the calls for integrated and adaptive approaches, reflect the dominance of the inflexible engineering water management regime within which water-related decisions are being taken in Greece. More specifically, water governance in Greece refers to an inflexible structure, where 'participation, decentralisation, democratic decision-making, networking and integrative approaches, are still limited' (Zikos & Bithas, 2006, pp. 166), reproducing a disabling environment for adaptations of a more transformative nature (Termeer, Dewulf, & Biesbroek, 2017). Considering this realisation to be a rather important point for the Greek islands' water management and governance context and thus a significant potential contribution of the 'adaptation pathways' approach, we will further elaborate on it in the next section.

THE (SOUTHERN AEGEAN) ISLANDS AS LABORATORIES FOR THE ADOPTION OF AN 'ADAPTATION PATHWAYS' APPROACH TO WATER MANAGEMENT AND GOVERNANCE?

Our analysis of the situation in the Southern Aegean islands has not been exhaustive (for a summary of this analysis see Table 1). However, through this analysis we positioned the challenge of adapting to water stress within the overall social-ecological development challenge of the islands. Thus, we brought to the surface certain issues referring to vulnerability trade-offs, economic and institutional path-dependence, the lack of science-policy interactions and long-term strategies, and a problematic decision-making context preventing the improvement of adaptations and/or the promotion of transformations. In other words, we examined the social-ecological context in the Southern Aegean islands within which 'adaptation pathways' emerge, as well as the relationship between adaptation to water stress, underlying development priorities and the dominant values that finally determine a water-related pathway choice (Pelling, O'Brien, & Matyas, 2015). Such a perspective on the issue of water stress and the adaptation challenges of the Southern Aegean islands is rather innovative at least for the Greek context, which has not embraced the IWRM paradigm yet. More specifically, this framing of the water stress problem brings into the focus of the water management and governance process political, economic and procedural implications that the dominant approaches of Greece's engineering water management regime do not address, mainly because they are considered to be either outside the scope of water-related decision making responsibilities or part of a status quo that has to be accepted as it is. In the words of the DEYAR Technician in Rhodes (Interviewee 2, 2017),

> 'We are responsible only for ensuring that the diverse water needs are covered from a technical point of view. I do not know who is or should be responsible for some broader consideration of the issue the way you describe it, I believe the regional authorities, maybe through some kind of regional plans? But in any case we are in Greece; you know how things work…'

The phrase 'we are in Greece, you know how things work' is a phrase that was mentioned often by the different interviewees implying their belief that the institutional and cultural contexts of the country disable the adoption of the contemporary approaches to water resources management and governance, according to the 5th critical dimension on the prevailing rules, values and knowledge. Thus, when asked about the possibility of a paradigm shift to an adaptive and IWRM approach in Greece, Interviewee 4 – Public Official in the Ministry of Environment and Energy (2017) responded,

> 'Greece has not embraced the principles of an IWRM approach. The WFD provided us probably the only tool that we use today for the monitoring

of the water situation through the River Basin Management Plans. This is not enough but it is a big step. As I said before, we are in Greece...'

According to the above and considering that the framing of a problem largely defines the space of solutions that are being discussed, it should not come as a surprise that the main water-related strategy for the Southern Aegean islands discussed at the national level is the development of desalination plants that are expected to ensure each island's self-sufficiency in water resources (Interviewee 4 - Public Official in the Ministry of Environment and Energy, 2017; Zotalis et al., 2014). Despite the ambivalence of the strategy[31], under certain conditions, this could be a valid adaptation choice for certain islands. However, such a choice further establishes the rationale of perceiving the issue of water stress on the islands as a function between the amount of demand and this of supply and, thus, as a quest to increase water supply in order to 'serve' tourism development raising new questions in terms of environmental justice, environmental integrity and social-ecological resilience. In addition, the ecological trends and drivers of change to the Water-Tourism SESs of the Southern Aegean, in combination with increasingly competitive water functions and stakeholders could make one wonder if another purely 'technical approach to water management in order to sustain the tourism industry may simply be postponing the inevitable outcome?' (Essex et al., 2004, pp. 24). In other words, taking the example of Rhodes and its recent water crisis (see paper 2 in this thesis), if decision-makers are currently not even in the adaptive space, then all pathways may be maladaptive (Wise et al., 2014). In this case, without at least considering transformative choices, an adaptation could remain limited to protecting existing systems properties, even where these are associated with the structural causes of risk, which can build pressure for eventual systems collapse (Pelling, O'Brien, & Matyas, 2015). Then the question arises: how to generate a transformation towards an 'adaptation pathways' approach to water management and governance in places such as the Southern Aegean islands?

[31] Many of the existing desalination plants are considered to be inadequate or are non-operative due to the lack of financial support by the government or bad management (Stathatou & Kampragou, 2014). Furthermore, the cost of desalinated water in Greece (above 1.2 €/m3) is relatively higher compared to the cost of large desalinations plants, like those operating in Israel, Malta, and Cyprus (below 0.7 €/m3) due to the small size of the Hellenic plants and their age (Sauter et al., 2013). This has gradually led many municipalities to be unable to cover the expenses, especially due to recent cuts in subsidies by the government (Koroneos, 2014). Other issues connected to desalination are the environmental pressure and the water losses due to the old hydraulic networks (Garnier, 2014).

Critical dimensions of the adaptation challenge	Application on the Southern Aegean islands
Multiple interacting changes	**Tourism**: dramatic increase in population during the summer months and increase of per capita water consumption **Climate variability:** High exposure and vulnerability to drought. **Climate change:** Scenarios for more heat waves and periods of drought, available water resources decrease, while water demand increases. **Supra-island water governance:** Often not in line with the local adaptations, evolutions and needs. Evidence of adaptations' spatiotemporal scalar mismatches that amplify vulnerability to water stress.
The quest for sustainable adaptations	**Vulnerability trade-offs in terms of hazard exposure:** Looser environmental legislation and a pro-growth planning with fast-track investments to adapt to the global economic crisis increase the exposure of the islands to hazards relating to an unsustainable tourism growth **Vulnerability trade-offs in terms of time:** Short-term coping strategies (e.g. expansion of boreholes network in Rhodes) in the absence of long-term plan and monitoring temporarily reduce the sensitivity to water stress yet increase the overall vulnerability in the longer term
The challenge of path-dependency	**Clear manifestation of the 'insularity and islandness model'** Mass tourism monoculture, 'monofunctionality' and over-reliance on the environmental capital The economic success of the current development pattern, the political power of the tourism sector, and the diachronic abandonment of other options limit the islands in their adaptive capacity
System state and thresholds identification	**Incapacity to take evidence-based decisions** Lack of monitoring of the water resources situation Lack of data about water demand/consumption and availability Prevalence of empirical knowledge/lack of scientific input Short-term uncoordinated practices for water management, tourism development and regional planning
The role of prevailing rules, values and knowledge cultures	**Disabling environment for adaptations of a more transformative nature** Water stress perceived as a simple function between the amount of demand and this of supply A locked-in situation of covering an increasing water demand by increasing water supply to serve tourism development Lack of long-term approaches, focus on incremental adaptations for Inflexible engineering water management regime Limited participation, decentralization, democratic decision-making, networking and integrative approaches

Table 1 - Summary of the application of the 'adaptation pathways' critical dimensions on the Southern Aegean islands. Source: Author

Wise et al. (2014) mention that for a transformation to be generated, intervention from higher levels of governance is likely to be needed. The WFD, representing the supra-island governance of the Water-Tourism SESs under consideration, has enhanced, to a certain point, elements of sustainability, participation, and evidence-based decisions regarding water policies in Greece (Demetropoulou et al., 2010). Similarly, the regional authorities see the EU's demand for development of regional climate change adaptation plans as an opportunity to collect certain data and inform their strategies accordingly, recognizing the role of the EU in contributing to the water-related considerations in the islands (Interviewee 1 – Public Official for Regional Development, 2017). Although such a top-down input can be relevant, in this paper, we have already underlined the need for place-based approaches that take into consideration local to broader scales in order to advance proper and equitable water management and governance solutions (Castro et al., 2018). Thus, could we consider an island as the scale of reference to enable a transformation to an 'adaptation pathways' approach?

Baldacchino (2007, pp. 6) sees islands as 'potential laboratories for any conceivable and uninhibited human project, in thought or in action' and also as 'sites of innovative conceptualizations'. In this sense, islands are acknowledged as test-beds for experimentation with, possibly innovative, interventions. This claim of Baldacchino (2007) is based on the premises that a) the distinctiveness and manageable size of islands provides the opportunity for a more thorough control of the intervening variables and experimentation to achieve desired outcomes, and b) the several limitations imposed on islands, due to their geographic situation, call for and may bring up needs-driven innovations. The recently established 'Smart Islands Initiative', a bottom-up effort of European island authorities and communities, showcases that the reasoning mentioned above is lately being manifested in practical applications and policy-making (Interviewee 5 - DAFNI Network). The initiative portrays islands as 'living labs' to host pilot projects that could be later transferred to other geographically isolated areas or could be scaled-up in cities.

Under these conditions, one could indeed envision the Southern Aegean islands as laboratories for the development of 'adaptation pathways' approaches. In fact, during our fieldwork research, the interviewees representing the local authorities in Rhodes seemed positive to experiment and participate in a process of 'adaptation pathways' formulation. In the case of such a hypothetical implementation, one of the biggest challenges would probably be the development of governance interventions that encourage and generate the co-production of knowledge and learning among diverse local stakeholders and researchers-scientists (Ballard, 2005; Butler et al., 2014; Termeer, Dewulf & Biesbroek, 2017; Wise et al., 2014). These interventions constitute prerequisites for the development of approaches such as the 'adaptation pathways' (Wise et al., 2014), as well as for advancing equitable water governance solutions (Castro et

al., 2018). It would be rather challenging to achieve this in the Greek context, where public participation when it comes to water governance is rather weak (Demetropoulou, 2010). Nonetheless, this possibly unhostile context of the Southern Aegean does not render the attempt futile. The incorporation of the scientific research will encourage the consideration of medium and long-term horizons that are presently lacking from the management and governance approaches. This could finally provide the opportunity to address the systemic drivers of the Water-Tourism SES vulnerability by enabling a gradual, long-term change in the prevailing values and governance norms through double and triple-loop learning processes that would had not been generated otherwise (Butler et al., 2014; Maru et al., 2014; Pahl-Wostl, 2009).

CONCLUSION

In our analysis, we argued that the 'adaptation pathways' construct could be a relevant input to contemporary water resources management and governance, considering their common premises, goals, concepts and approaches. We use the word 'input' as we do not aim to ignore or replace the advances in the fields of water resources management and governance. Instead, we attempt to enhance them by providing primarily an additional lens to frame adaptive and integrated water-related decision-making that aims to address vulnerability to water stress in Water-Tourism SESs. Thus, we go beyond the usual analysis of water stress in tourism destinations as a simple problem of increased water consumption. We opted for a social-ecological approach and we conceptualised the related adaptation challenges through the five critical dimensions recognized by the 'adaptation pathways' construct.

The application of the five critical dimensions on the Southern Aegean islands revealed the strength of the 'adaptation pathways' approach, especially in bringing up political, economic and procedural implications that the dominant approaches of Greece's engineering water management regime do not address. Considering that these implications are directly connected to the IWRM principles, the 'adaptation pathways' could be a possible way for the Southern Aegean islands to eventually embrace the IWRM. To achieve this though there is a big challenge to overcome which refers to the established political and economic power of tourism that seems to profit from the current engineering water management regime. In this regard, it would be interesting to experiment on the 'adaptation pathways' implementation initiating from an island such as this of Rhodes, where the water crisis of 2017 has possibly caused certain disturbances to such arrangements between water and tourism.

Finally, we should mention that while the adaptive IWRM approaches are normally water-centred management and governance solutions, the 'adaptation pathways' for Water-Tourism SESs move beyond this towards the much needed place-centred solutions. In particular, the 'adaptation pathways' for Water-Tourism SESs provide the opportunity for the development of sustainable solutions that are defined by the place-specific social-ecological issues they address rather than by a single recourse they 'manage'. In this sense, the 'adaptation pathways' for Water-Tourism SESs could be further expanded to nexus analysis and decision-making (e.g. tourism-water-energy) in accordance with the needs of the sustainability sciences.

GENERAL CONCLUSIONS

The aim of this thesis has been to enhance our understanding of the complex relationship between humans and the natural environment, and to investigate decision-oriented approaches that can navigate social-ecological complexity and promote sustainable development. The water-tourism complex and, more specifically, the link between water stress, tourism, climate change, vulnerability, and water governance, constituted the empirical domain through which this thesis achieved its aim. The island of Rhodes in the Aegean was the laboratory (or case study) where the theoretical framework of the thesis has been applied for an empirical analysis that informs theory. In the following paragraphs, we will discuss the main findings and results, the overall academic contribution of the thesis, the limitations and the questions arising for further research. To start with, we will present the main findings of this thesis by responding to the research questions (RQs).

RQ1. Paper 1. *How to imagine new planning approaches upgraded by our latest understanding of planning through the complex systems?*

To reply to this question, we brought up evidence and characteristics of a systematic 'complexity turn' in planning. After following a series of considerations that revealed implications of the complexity sciences into planning approaches, we conceptualized this 'complexity turn' through the adaptive rationale; an additional normative and analytical trajectory in planning theory that has yet to be defined. To contribute to the definition of the adaptive rationale and its operationalization, we argued on the need for this adaptive rationale, as well as the subsequent adaptive planning approaches, to be embedded within the concept of normative sustainability. This, because the analysis demonstrated a major challenge when trying to revisit planning through complex systems' approaches. The challenge to attribute ethical and political dimensions in so far neutral, for the natural sciences, concepts such as adaptation, self-organization, and emergence. Furthermore, the investigation concluded on the need for this new generation of adaptive planning approaches to be based on post-normal approaches to science, where the technical 'facts' together with the communicative 'values' find themselves in a dialectic, equal and issue-driven relationship.

RQ2. Paper 2. *How do water demand and governance interact with environmental dynamics to increase the vulnerability to water stress of insular tourism regions?*

From this question on, the research interest of the thesis was focused on the empirical domain of the water-tourism complex. Thus, our analysis proceeded through a (complex) social-ecological systems (SESs) approach, and, more

specifically, through what we defined as a Water-Tourism SES approach. This framework was then applied to the island of Rhodes. The empirical analysis revealed the social-ecological interactions generating the vulnerability to water stress on the island providing a place-specific response to the research question. More specifically the findings referred to: a) a socially acceptable vulnerability trade-off between water stress and tourism success, b) the contribution of spatiotemporal scalar mismatches of the social adaptations to the vulnerability to water stress, c) the transformation prospects of Rhodes after a water crisis. Overall, our investigation demonstrated that it is important to go beyond usual analyses of water stress in tourism destinations as simple problems of increased water consumption, leading to the depletion of the resource, as well as over-simplistic measures of tourism sustainability, such as the island's carrying capacity. Such kind of analyses seem to be of little instructive value and to contribute to a vicious circle in decision-making and water-governance processes of continuous attempts to increase supply in order to cover an ever-growing demand. Instead, more emphasis needs to be placed on the intervening variables (local values, institutions), and on contextual factors (tourism, climate variability and change) affecting the relationship between water stress and tourism. The Water-Tourism SES framework was thus developed in order to cover this need specifically.

RQ3. Paper 3. *How to formulate adaptive Integrated Water Resources Management (IWRM) and governance approaches that could promote resilience to water stress issues and overall sustainable development in insular tourism regions?*

To answer to this question, we further elaborated on the 'adaptation pathways' approach by framing it to the management and governance of water resources in insular tourism regions vulnerable to water stress. Our analysis demonstrated that the 'adaptation pathways' could be a relevant input to contemporary water resources management and governance, considering their common premises, goals, concepts, and approaches. Following a more place-specific and context-sensitive consideration that focuses on the Southern Aegean islands in Greece, we also demonstrated that an 'adaptation pathways' approach is a rather innovative approach for the Greek context which has not embraced the IWRM paradigm yet. In this regard, the ‘adaptive pathways’ potential contribution lies especially on the fact that it brings into the focus of the water management and governance process political, economic and procedural implications, which the dominant approaches of Greece’s engineering water management regime do not address. Our analysis proposed an additional lens to frame adaptive and integrated water-related decision-making for Water-Tourism SESs, through a more place-centred rather than water-centred perspective and based always on the co-production of solution-oriented knowledge by real-world actors and scientists. It becomes clear that the findings of RQ3 (and indirectly the findings of RQ2) feed back to the RQ1 and the overall aim of investigating the proper rationales to address complex (social-ecological) issues.

The thesis has brought together many different disciplines and concepts that are all being benefited from the findings giving the opportunity for several and mutual contributions. To name a few, the planning-complexity relationship has been informed with considerations on normative sustainability and post-normal science. The SES approach we followed contributes to the tourism literature by proposing an alternative understanding of sustainability and resources management in tourism. At the same time, it contributes to the concept of SESs by including the less researched issues of water resources and tourism development. Similarly, by combining the 'adaptation pathways' with considerations on water and tourism in the islands we offered a decision-oriented framework that contributes to water-tourism-climate-island literature together. The main strength of this thesis' overall theoretical contribution lies in this combination of a series of theories and concepts such as complexity theory, planning theory, SESs, normative sustainability, vulnerability, water governance and tourism. This thesis has accomplished the goal of inquiring and analysing these theories and concepts in an interdisciplinary way, putting them along with their respective scientific disciplines in a dialectic relationship in order to open paths and weave new approaches to the complex social-ecological issues under study. The ultimate aim of this thesis along with this interdisciplinary approach make this effort a timely and valid scientific contribution not only to the individual disciplines mentioned already but also to the so-called sustainability sciences. In addition, this interdisciplinary effort presents and elaborates on a transdisciplinary vision, which directly connects to the currently unwrapping needs of the contemporary sustainability sciences research. It does so at least by envisioning the new generation of adaptive planning approaches to be based on post-normal approaches to science (paper 1) and by later discussing one such possible approach insisting on the need for co-production of solution-oriented knowledge between researchers and real-world actors (paper 3).

In terms of methodological contribution, the Water-Tourism SES framework, introduced in paper 2 and further elaborated in paper 3, constitutes not only an enhancement of Ostrom's SES framework but also an innovative methodological framework for the investigation of the issue of vulnerability to water stress in the tourism research. More specifically, the Water-Tourism SES framework, as the result of SES, water and tourism, and vulnerability research, provides a methodological framework that tourism studies were lacking so far insisting to perceive the water problem in the tourism areas mainly as a problem of consumption and neglecting other dimensions. In this thesis, the Water-Tourism SES framework has been mainly used as a conceptual framework rather than as a strict methodology for the analysis. Nevertheless, as it happens also with Ostrom's framework, one can easily adjust it to the needs of a different future research and can then use it to guide methodologically the empirical investigation of its parameters.

Another important contribution of the thesis is case-study related. This thesis constitutes the first scientific attempt that aimed at understanding the issue of

water stress in Rhodes through a social-ecological systems approach. According to my knowledge, this thesis is also the first scientific research that documents and investigates the water crisis of 2017 on the island (paper 2). It is also worth mentioning that the analytical approach used in this research is innovative for the Greek context in general. The issue of insular-tourism-sustainability implications is popular within the Greek scientific community. However, the approaches used so far refer to less contemporary analytical frameworks (e.g. carrying capacity) or to purely quantitative technical works focused on water resources management. Similarly, the 'adaptation pathways' in paper 3 is a framework that bring normative dimensions to for decision-making and water governance that is innovative for the Greek context, in general, and the Southern Aegean islands, in particular. In this regard, except for its academic contribution, the thesis reflects on local governance and policy implications that could be used to apply to the real-world problems on the islands under study (and not only on them).

To achieve its aim, this thesis had often navigated into uncharted territories in an exploratory way. Therefore, it constitutes an interesting contribution but it also encloses limitations and raises new questions for further research. An important issue for additional research is the further definition of the 'adaptive rationale'. In the first paper of this thesis, we attempted to define the adaptive rationale through an analysis of theoretical considerations embedded within scientific research and planning theory. However, the research presented in paper 3 makes us reflect: If the adaptive rationale already underpins recently developed planning approaches to complex phenomena, then an analysis and assessment of the characteristics of such proposed or implemented solutions could maybe inform theory and the characteristics of the ‘complexity turn’. Due to the current proliferation of solution-oriented applied interdisciplinary research, maybe a step back to inform planning’s evolution in terms of theory is a valid choice.

Another limitation of this study lies in its interdisciplinary and integrated perspective. Due to the combination of many different theories and concepts and the attempt for an interdisciplinary and integrated perspective to the phenomena under research, the thesis may have missed to provide more in-depth insights to certain of the issues discussed. For instance, as already mentioned, in this research, the Water-Tourism SES framework has been applied in a ‘loose’ way in order to provide guidance for the case-study analysis. Further research could provide a more in-depth consideration of the new variables and tiers proposed in order to better connect it with Ostrom’s considerations, and more strictly apply it to a case-study analysis.

At this point, it should be mentioned that the application of the Water-Tourism in Rhodes was especially challenged by the lack of proper already existing data. The interviews provided sufficient and relevant information for the needs of our research. However, since these interviews proved to be the main possible sources of information, further research is needed as interaction with more diverse local

stakeholders could provide further insights and document local knowledge. In addition, this thesis has shared the vision of a future transdisciplinary effort that would attempt the implementation of the 'adaptation pathways' approach on the islands of the Southern Aegean. Considering that in general terms, the insular Mediterranean makes sense as a unit of analysis, there could be an even more interesting scenario referring to the implementation of the 'adaptation pathways' approach in different Mediterranean islands and the monitoring of the process and results through a comparative approach. Such a research could potentially inform the 'adaptation pathways' approach and tailor it for the context-specific challenges of insular tourism islands. Furthermore, it could help the identification of those parameters that enable the emergence, adoption, and implementation of the new paradigms in water governance and climate change adaptation in insular tourism regions.

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