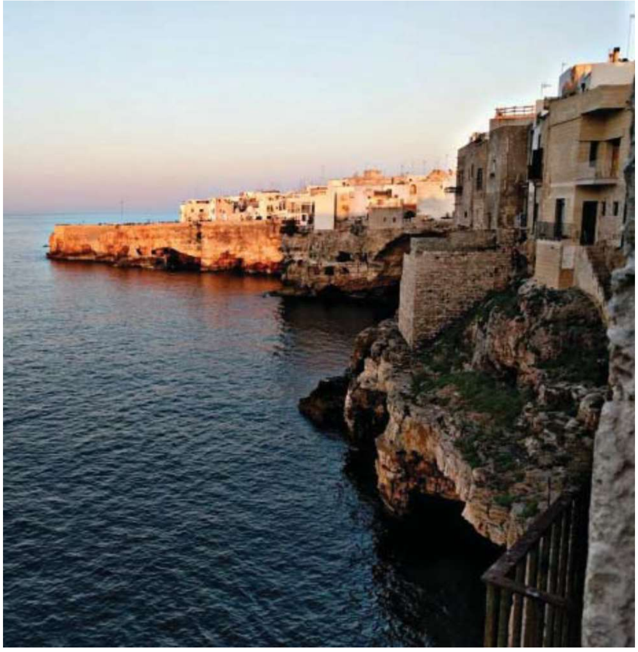

# INTEGRATING PARTICIPATORY MODELLING IN RISK MANAGEMENT


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*ABSTRACT*

*Participatory modelling (PM) techniques aim at involving stakeholders and local communities' knowledge to support risks assessment management in social-ecological systems (SES). Understand SES complexity means consider unique socio-economic and cultural values, direct and indirect experiences, political characteristics that have influenced the formation of a community's risk understanding and local knowledge. Comprehending the complexity of these interactions could help to exchange information and knowledge, leading to a better comprehension of the problem formulation through social learning processes and to facilitate conflict resolution. Evidences demonstrated that there is the need to require not only a deep understanding of the main physical phenomena to be addressed, but also a knowledge about stakeholders' type, level of cooperation between different stakeholders and their risk perception. Once the problem is well understood, and stakeholders included in the process, it is possible to find more efficient adaptive management solutions to enhance the resilience of the system. For this reason, to improve risk management processes, it should be considered physical risk and social response in an integrated way. Starting from a literature review, the aim of this work is to demonstrate the role of PM techniques in adaptive risk management to collect knowledge and improve SES management. Specifically, coastal systems (CS) have been analysed. CS are particularly vulnerable to climate change negative impacts. In this sense, it is important to understand that vulnerability is socially constructed and not only determined by the occurrence of a physical event.*



*KEYWORDS*

*Participatory Modelling; Social-ecological Systems; Decision Support Systems; Coastal Systems; Adaptive Management*

## 1 INTRODUCTION

A SES perspective helps to place regime shifts within an integrated human-environment context in which social outcomes are contingent upon ecological processes and vice versa (Nayak, 2014). Berkes and Folke (1998) define SES as complex system. Understand SES complexity means consider unique socio-economic and cultural values, direct and indirect experiences, political characteristics that have influenced the formation of a community's risk understanding (Renn & Rohnmann, 2000) and local knowledge refers to the actor's information about environment in which they live (Robertson & McGee, 2003). To collect these information, PM techniques represent a tool for involving stakeholders and local communities' knowledge to support risk assessment management in SES.

Specifically, "participation to support the decision" to manage the complexity in coastal zones would help to address the most efficient solutions to make the most of the natural resources available in a broad and flexible manner (Elliff & Kikuchi, 2015).

In this paper, through a literature review, CS as SES will be analyzed, to understand the role of PM techniques in adaptive risk management. CS are particularly vulnerable because of resources overexploitation of and the overdevelopment in terms of urbanization and infrastructures. Furthermore, they are also vulnerable because of climate change negative impacts (Marengo et al., 2017; Masselink & Gehrels, 2014; Usaid, 2009).

For these reasons, it is necessary to better understand the complexity of the linkages between CS evolution and human society, improving a historically-informed understanding of the interconnections between cities and their environments and particularly between cities and the sea (Mosley, 2014).

## 2 THE ROLE OF PARTECIPATORY MODELLING IN ECOSYSTEM BASED MANAGEMENT

In the last years, several scientific approaches on natural risk management have conceived SES as complex and adaptive systems (Pollnac et al., 2010). The most notable example to deal with complexity in SES is Ecosystem Based Management (EBM) (Giebels et al., 2016). EBM has been advocated at international level as the best strategy to cope with climate change, lands and oceans protection and to manage human activities in a sustainable way (Arkema et al., 2017; Bigagli, 2016). For instance, several European case studies on the application of an EBM approach to improve ecosystem services are available in scientific literature (Bigagli, 2016; Giebels et al., 2016; Long et al., 2015)

EBM stresses the need to perceive SES as complex systems formed by human and environmental elements (Giebels et al., 2016).

Berkes and Folke (1998) define SES as complex, integrated systems in which there are a mutual feedback between ecological and social subsystems (Nayak & Armitage, 2018). SES are characterized by uncertainty of information, non-linearity of process and self-organization that results (Levin, 1999), and unpredictable effects also across scales (Giebels et al., 2016).

SES complexity is due as different fields, actors and policy levels are involved (Bache & Flinders, 2004; Paavola et al., 2009; Pierre & Peters, 2000). Since policy levels and actors are multiple in such settings, (Bache and Flinders, 2004) complexity management might be necessary (Cash et al., 2006). This seems true for complex issues related to environment, where decision-making processes are amplified or attenuated by public hierarchies to multisectoral, transversal, and holistic collaborative arrangements (Ricart Casadevall,


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2016). Long et al. (2015) listed the key information to develop an EBM strategy as assessment of nature of ecosystem considering spatial and temporal scales, inclusion of adaptive and integrated management, use of scientific knowledge, stakeholders involvement to collect information and knowledge about human-environmental network. Literature shows the existence of different types of participation including a diverse range of activities: from passive participation, in which the objective is just to inform people, to co-management, in which the participants perform the syntheses and include them in a joint decision making process (Voinov and Brown Gaddis, 2008). This paper focuses on "participation to support the decisions". Several examples show the importance of stakeholders' involvement in order to increase the effectiveness of decision support system (DSS) (Sandink, et al., 2016).

### 2.1 PARTICIPATION TO SUPPORT THE DECISIONS IN ORDER TO MANAGE THE COMPLEXITY OF SES

Using 'participation to support the decisions' to collect knowledge and manage the complexity of SES offers three main benefits. According to Maskrey et al, 2016: (i) normative benefits, that enhance citizen empowerment, equity and social justice in decision making process (e.g. Renn et al., 1998); (ii) instrumental benefits, that enhance the legitimacy of evidence and decisions, and the trust that is afforded to them (e.g. Gaddis et al., 2010; Voinov & Bosquet, 2010) and (iii) substantive benefits, that enhance the quality of the decisions (e.g. Stirling, 2006). Despite these advantages are recognized in many case studies, often stakeholders are not involved in the decision process (Sandink et al., 2016). This depends on community policies, engagement strategies, lack of funding (McIntosh et al., 2011; Quinn, 2010). One of the most common causes of DSS failure is the limited problem understanding due to a failure to structure or a lack of information (Quinn, 2010). According to Tsoukiàs (2008), for a given representation of the problem situation the analyst proposes to the stakeholders a "problem formulation". An understanding of the problem situation is considered a starting point in the stakeholder engagement and DSS development process. There is not optimal mode to stakeholders' involvement in the development of DSS but the choice is based on the socio-environmental context (Sandink et al., 2016). However, many authors have articulated general principles and practices in order to improve the effectiveness of the DSS process (E.g. McIntosh et al., 2011; Voinov & Bousquet, 2010). Some examples have been highlighted as an initial discussion between stakeholders, before the process begins, in order to correctly structure the problem situation (McIntosh et al., 2011); the inclusion of experts and non- experts knowledge (Oliver et al., 2012). A knowledge gap still exists about which type of factors we need and in which type of context (Runhaar, 2009). Understanding the interactions among different decision-makers is a relevant step for mitigating the conflicting interpretation of information due to differences in knowledge, values and beliefs (Giordano et al., 2017; Wolbers & Boersma, 2013) and to increase stakeholders' awareness about a problem situation to improve DSS process. To this aims, taking PM in EBM, and specifically use the 'participation to support the decision' to manage the complexity in coastal zones, would be to address the most efficient solutions to make the most of the natural resources available in a broad and flexible manner (Elliff & Kikuchi, 2015). Understanding the relationships among CS and people reflects an important and international sustainability challenge (Armitage, 2007).

## 3 THE CASE OF COASTAL SYSTEMS

CS are naturally dynamic systems, subjected to modifications of forms and processes at different time and space scales due to geomorphological and oceanographical factors (Mustelin et al., 2010). In particular, they


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constantly change in response to winds, waves and tides (Mustelin et al., 2010). Coastal areas are the preferred sites for urbanization (Masselink & Gehrels, 2014). As a matter of fact, more than half of the worldwide population live within 100 kilometers from the coastline (Leslie et al., 2015) and the population density is larger than the average with future population growth projections that are the highest worldwide (Masselink & Gehrels, 2014).

Many uses are taking place in the coastal zones for the wide range of essential resources and activities, e.g. human occupation, navigation and communication, living marine resources, mineral and energy resources, tourism and recreation, coastal infrastructure development, coastal environmental quality protection and beach and shoreline management (Masselink & Gehrels, 2014).

Some of these uses produced the overexploitation of resources and the worsening of CS resilience ( Marengo et al., 2017; Masselink & Gehrels, 2014; Usaid, 2009). In particular, as highlighted by Masselink and Gehrels (2014) the "overdevelopment of the coast in terms of urbanization and infrastructure has significantly increased our vulnerability to coastal erosion and flooding".

Moreover, CS are vulnerable to climate change impacts, in particular by the pressures given by sea level rise (Masselink & Gehrels, 2014; Usaid, 2009). Climate change will continue to impact coastal communities, affecting approximately 2.7 billion people, and ecosystems, increasing the exposition to specific hazards such as flooding, coastal erosion, salt water intrusion and ecosystem loss together with extreme climate events (Adger, 2005; Dolan & Walker, 2017; Usaid, 2009; Marengo et al., 2017; Mosley, 2014; Mustelin et al., 2010; Raadgever et al., 2016; Tobey et al., 2010). These biophysical changes exacerbated by climate change would provoke several socio-economic impacts such as loss of infrastructures and coastal resources with the decline of economic, ecological, cultural and subsistence (Masselink & Gehrels, 2014; Najib et al., 2015).

## 3.1 MANAGING THE COMPLEXITY OF COASTAL SYSTEMS

In the light of the above, it is necessary to better understand the complexity of the linkages between CS evolution and human society, improving a historically-informed understanding of the interconnections between cities and their environments and particularly between cities and the sea (Mosley, 2014).

According to Usaid (2009), vulnerability assessment for climate change in coastal areas regards three factors "i) the nature and magnitude of climate variability and change; ii) the human, capital, and natural assets that will be exposed to and impacted by climate change; and iii) the current capacity of coastal communities and ecosystems to adapt to and cope with climate impacts" (Usaid, 2009).

In this sense, vulnerability, seen as a sum of actions and processes, should be considered as a socially constructed and not only determined by the occurrence of a physical event (Dolan & Walker, 2017; Mustelin et al., 2010). In CS an increase of adaptive responses will be required to cope with the negative impacts enhanced by global environmental change (Adger, 2005).

As stated by Weinstein et al. (2007) "the successful implementation of sustainable coastal management depends on, and is driven by, societal values." There is the necessity to better understand the human-induced causes and the social drivers of environmental changes and the way human behaviors could coincide with environmental and social priorities (Weinstein et al., 2007).

Literature underlines the necessity to improve science-based and participatory decision-making processes for effective management of CS (Granek et al., 2010) and states EBM as one of the approaches put forward to improve management (Christensen et al., 1996; Granek, 2010; McLeod et al., 2005; Slocombe 1998).


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Just to give some examples, in the Urdaibai Estuary (Basque Country, Northern Spain), as in many other Mediterranean coastal zones, many different interests coexist resulting in difficulties to manage the system in a sustainable way leading to a great challenge. Thanks to a two-year collaborative research process, the improvement of the integration of different expertise and values, through a mutual learning process, led to define relevant policy options and decisions in the face of complexity, value conflict and unavoidable uncertainty (Garmendia et al., 2010). Furthermore, Boström, Dreyer, and Jönsson (2011) focused their research on the challenges for stakeholder participation and risk communication in the Baltic Sea. What emerged from this study was that the inclusion of a broad range of actors has the potential to facilitate environmental risk governance.

Risk and vulnerability perceptions of stakeholders and local communities play a crucial role in building inclusive and responsive decision-making adaptation processes (Bonatti et al., 2016; Slovic, 1987). Moreover, the investigation of public perceptions is necessary for the comprehension of adaptation and transforming vulnerability states (Bonatti et al., 2016; García de Jalón et al., 2013). Community level perceptions nowadays and historical memory could also help to investigate the peculiarities that enable and/or constrain communities to respond, recover and adapt (Mosley, 2014). In this sense, it seems clear that scientific views of changes could be more efficacious with the inclusion of local knowledge systems ( Marengo et al., 2017; Mosley, 2014).

Coastal communities need to enhance their knowledge of local climate change consequences and to explore preferences for adaptation options, to build resilience of CS (Marengo et al., 2017).

For this reason, there is the necessity and urgency to include coastal communities' participation in coastal adaptation strategies as part of effective coastal management (Usaid, 2009).

As a matter of fact, it seems clear that risk adaptive management strategies should be considered more and more as a governance issue because they are not only a technical matter (Raadgever et al., 2016). It is important to work in the direction of proactive adaptation strategies because they "aim to address the full range of coastal climate change hazards in ways that meet social objectives" (Tobey et al., 2010).

## 4 CONCLUSION

Starting from a literature review, the paper has tried to demonstrate the role of PM techniques in adaptive risk management to collect knowledge and improve SES management.

As a matter of fact, it has been highlighted that expert knowledge is insufficient to deeply understand a problem situation. Instead, it is recognized that in many decision-making processes the adoption of a participatory paradigm is needed to build a co-production knowledge. PM techniques, and specifically the "participation to support the decision" type, are very important to increase the effectiveness of DSS of problematic situations and, despite an increasing array of successful applications of a PM in EBM approach towards climate change impacts in coastal environments, planning and implementing adaptation strategies is still under development.

Furthermore, the analysis of the case of CS allows to highlight the necessity to improve science-based and participatory decision-making processes for effective adaptive management.

In this step, the analysis of general risks on CS has been taken into consideration. Moreover, the research will continue through a more deeply analysis of one of the main risks due to the increase of the exposition to specific hazards related to CS.


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