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Applying network analysis to assess coastal risk planning

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ABSTRACT

Adequate response to risks affecting coasts requires an integrated and coordinated multi-risk governance system, with ongoing evaluation of statutory planning documents and responsible stakeholders. Traditionally, such analyses have been carried out using mainly qualitative approaches. This paper adopts a more systemic and quantitative perspective on assessing planning systems and stakeholder relationships in connection with coastal risk. We apply network analysis to the Catalan coast (Northwestern Mediterranean Basin), paying special attention to the level of climate change integration in the planning system, as an aggravating factor of current risk dynamics. Our results demonstrate and quantify the complexity of Catalan coastal risk planning, which requires dealings with multi-level legal and administrative frameworks. Also highlighted is dissimilar management traditions according to risk type: the perspective on flooding risk is more unified and multi-risk focused, whereas coastal erosion (a significant issue for the Catalan coast) is managed more sectorially from a centralized administrative level. Climate change, moreover, is weakly accounted for in current statutory planning. We also acknowledge the relevance of using qualitative information as an important complement in interpreting results and making policy recommendations.

1. Introduction

Coasts are some of the most valuable ecosystems on Earth in terms of biodiversity and productivity but also as providers of ecosystem services that guarantee human development and well-being. The growing urbanization of coastal areas, combined with climate change, aggravate both risks and their damaging consequences. Risk management — a systemic and a complex issue (Renn, 2008) due to inherent uncertainties, multi-scale dynamics and many competing interests (Functowicz and Ravetz, 1992) — is particularly important for coastal areas in that many physical, environmental and socioeconomic components are simultaneously affected by natural and anthropogenic threats.

This situation requires an integrated and strategic approach to coastal management that has gained importance in Europe since 1999 (Ballinger et al., 2010). The European Union has committed to the implementation of a programme for Integrated Coastal Zone Management (ICZM) in order to deal with the complexity of coastal risks. ICZM is a process for harmonizing a range of policies and decision-making structures so as to facilitate concerted action aimed at achieving sustainability goals by taking into account the interconnectedness of biophysical and socioeconomic components of coastal systems (Reis et al., 2014). ICZM also highlights adaptation as one of the most promising principles for promoting the sustainability of coastal areas. This multidimensional approach, which is of relevance to different management areas, ranges from technical strategies to cope with climate change (such as options for "working with nature") to the design of appropriate governance systems.

Our interest lies in governance, given that institutional aspects — such as statutory planning and coordination between authorities — will enhance or limit ICZM effectiveness. From this perspective, risk governance requires an integrated, holistic, multi-risk planning approach which should incorporate all phases of risk management (prevention to emergency) and which should take into account participation by a wide range of stakeholders (Ribot, 2008) in an ongoing assessment process. Understanding governance systems, planning and stakeholder relationships in a risk management context is essential to improving the sustainability of coastal environments (Olsen, 2000). Our focus on networks is relevant, given that the number and variety of stakeholders, their relationships and their level of coordination and integration in natural resource management may foster or impede the implementation of more risk-adaptive management strategies (Bodin and Crona, 2009; Janssen et al., 2006).

The study of networks reflecting stakeholder complexities and how these can contribute to improving sustainability issues is championed by Eleanor Ostrom (2005, 2010), who has shown, for

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instance, how horizontal, multi-scale structures with interacting networks are very suitable for the management of natural resources. Moreover, diversified networks composed of different types of stakeholders encourage cooperation across different scales and political and physical boundaries (Peters and Pierce, 2004; Reed and Bruyneel, 2010). Collective learning and the development of expertise are both fostered when complex problems are dealt with and negotiated within this type of network, which reflects multiple perspectives on knowledge (Cundilla and Rodelab, 2012). Folke et al. (2005) have also shown how social networks can promote accessibility to, circulation and communication of different types of reliable information. Network analysis based on graph theory is a quite a novel approach, yet it seems particularly suited to dealing with power relationships and knowledge distribution in the management of natural resources, as demonstrated by several authors (Berkes et al., 2003; Adger et al., 2005; Bodin and Prell, 2011; Crona and Bodin, 2006; Crona and Parker, 2012; Franquesa and Budapest-Mengual, 2009; Roca et al., 2014). Network structures affect the ability of actors stakeholders to cooperate, share information and adapt their behaviour to new circumstances (Berardo et al., 2017).

Social network analysis has, to date, been little used in the field of coastal management (Roca et al., 2014), even though it is a powerful means for quantitatively measuring the number, types and intensity of interactions between social groups. Traditionally, the methodologies used for coastal management have been mainly qualitative and fragmented, based as they are on legal documents, grey literature and stakeholder-provided information and observations.

The purpose of the paper is to use network analysis as an integrative, systemic and quantitative approach to assessing relationships between coastal risk planning systems and stakeholders. The ultimate goal is to gain a deeper understanding of coastal risk governance and to assess the degree to which climate change — as a relatively new issue — is integrated in planning systems in our setting. The case study focuses on the Catalan coast (Northwestern Mediterranean Basin) and how the interactions of statutory authorities within policy networks in the European context can hinder or promote ICZM. This focus on the role of formal stakeholders is key to decision-making power and planning integration especially at the regional and national scale (Fisher, 2017). Governmental actors are more stable and easy to define which contrasts with a previous research on the role of informal relationships of statutory and non-statutory authorities, where the boundaries and the characteristics of the networks were more diffuse and unstable but resulted relevant at the local level (Roca et al., 2014).

Multiple risks already converge in the Catalan coast (primarily beach erosion, flooding and marine pollution) and many studies suggest (Guillen, 2008; Jiménez et al., 2012) that the associated risk may be seriously aggravated by climate change, which especially affects vulnerable areas like Catalonia, with its deltas and densely populated coastline. Although the main contribution is methodological, the substantive results of our case study would be relevant to any Mediterranean area — and even to tourist areas elsewhere in the world — experiencing similar problems and risks.

2. Case study: The Catalan coast at risk

The Catalan coastline, in the northwestern Mediterranean region, is both ecologically and socially diverse. Nearly 600 km long, it is highly urbanized, given that around 70% of the 7.5 million inhabitants of Catalonia live within a 20-km wide coastal corridor. Infrastructures and artificial beaches occupy around 152 km of the coastline (Guillen, 2008).

Although this coast displays a large variety of coastal morphologies, such as cliffs, bays, deltas and curved and straight beaches, the few natural resources that remain are at risk from human pressures. Tourism, a major economic sector in Catalonia, with a capacity of some 1.4 million beds, is clearly one factor in this pressure.[1]

Natural pressures also affect the coastal fabric, including storm surges and rising sea levels. Erosion and flooding have been identified as two of the most common risks affecting the Catalan coast, as reflected in reports on coastal risk (Guillen, 2008) and climate change (Sánchez-Arcilla et al., 2012). The fact that one third of the Catalan coast (192 km) is undergoing erosion (Bosom and Jimenez, 2011) requires significant management efforts.

Flooding, in particular, is a major natural hazard, although the impact is not the same on every section of the seafront. Different levels of hazards (Fig. 1) have been identified, including areas at high risk (important river mouths and Barcelona), at intermediate risk (highly urbanized areas and sandy coasts) and at low risk (rocky areas).

Climate change forecasts point to an increase in certain risks that will significantly aggravate the situation of the Catalan coast. Of special concern is the fact that erosion is accelerating; it is already directly affecting certain sectors and is even causing the disappearance of the highly vulnerable Delta de l'Ebre (Guillen, 2008; Jiménez et al., 2012). Findings from climate change studies suggest that extreme events, such as severe storms and floods, are likely to become more frequent and to cause material damage and population displacement and to have adverse effects on food production and fresh water availability. Furthermore, tourism, a driving force in local economies in Catalonia, is likely to be greatly impacted by climate change (Sánchez-Arcilla et al., 2012).

Sea level rise is an important — although not the only — indicator of climate change. Interactions with atmospheric processes may lead to variations in surface winds which, in turn, may affect wave configuration. Changes in the characteristics of sea swells and storms also play a key role in determining the coastal impact of climate change. According to studies by Sánchez-Arcilla et al. (2012), by 2100 it is forecast that the Catalan coast will be eroded by about 100 m in the most vulnerable areas (e.g., Delta de l'Ebre in the south) and by around 70 m elsewhere. Since Catalan beaches range between 50 m and 100 m in width, they are consequently very vulnerable to erosion resulting from a combination of rising sea levels and increased duration and severity of sea storms.

Management of coastal risk in Catalonia is therefore a complex matter; not only does its physical diversity require multiple management strategies, there is also a great variety of stakeholders, interventions and interests at stake. Coordinated action by all stakeholders, but mainly led by public authorities and government departments, would enhance prevention policies regarding natural risks in Catalonia. Below we describe a network analysis methodology as a means to examine the structure of Catalan coastal risk management.

3. Methodology

In order to analyse Catalan coastal risk planning, network analysis complemented with qualitative techniques were used. A network, as a representation of the relationships within a system, is formed by a set of vertices (also called nodes) connected by a set of edges (also called links) (Newman, 2010). Multipartite networks were drawn with vertices representing plans, stakeholders and risks, and edges representing interactions among the vertices. Qualitative work was conducted to analyse the content of administrative documents in order to identify plans, stakeholders and risks and the interactions between them; this information was further validated, at the beginning of 2016, by 12 semi-structured face-to-face interviews, lasting 30–60 min, conducted with experts and administration representatives as follow-up to a semi-structured survey. The interviews were recorded and transcribed before

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