Environmental Science and Policy 77 (2017) 140–146

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Assessing adaptive capacity through governance networks: The elaboration of the flood risk management plan in Austria

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ARTICLE INFO

Keywords:
Adaptive capacity
Flood risk management plan
Social network analysis

ABSTRACT

One of the consequences of climate change is the increase in the frequency and entity of extreme weather events, including floods. Any strategy dealing with the various impacts of climate change must focus not only on mitigation aspects, but also on improving on the level of adaptive capacity. Over the past decades there has been an increase in the frequency and intensity of floods in Europe, a fact which has prompted the European Union (EU) to put forward the Directive 60/2007 (the 'Floods Directive'), requiring Member States to produce a comprehensive Flood Risk Management Plan (FRMP) by 2015. The purpose of this paper is to assess how the implementation of the 'Floods Directive' has contributed to the level of adaptive capacity in Austria, a EU member State hosting an important river basin. By relying on the existing literature, the paper first describes the governance system associated with flood risk management in Austria prior to the elaboration of the FRMP. Subsequently, based on collected primary data, the paper studies the governance structure associated with the elaboration of the FRMP in Austria by using descriptive social network analysis (SNA) and discusses the implications in terms of adaptive capacity of flood governance. The elaboration of the FRMP has had the merit of coordinating the pre-existing regional legislation into a coherent national framework, under the leadership of the Federal Ministry of Agriculture and Environment. A limited number of other public administration stakeholders act as brokers, but the overall governance structure appears centralized and exhibits low modularity. Such a structure, moreover, is exclusively composed of public administration actors with no de facto participation of other stakeholders (e.g., NGOs and private companies). The incorporation of a wider set of organizations in the earlier phases of the policy cycle is welcomed, in order to make the whole process less technocratic and effectively improve the overall level of adaptive capacity.

1. Introduction

One of the predicted consequences of climate change is the increase in both the intensity and frequency of extreme weather events, including floods (IPCC, 2014). In Europe an increase in the number of flood events and major flood events (i.e., flood events with registered casualties larger than 70 and/or direct damages larger than 0.005% of GDP) has been recorded over the period 1970–2005 (see Barredo, 2007). Between 1998 and 2009 over 200 major floods have occurred in Europe with overall economic damages estimated at 52 billion euros (European Environment Agency, 2011). Particularly damaging floods have occurred in the year 2002, affecting mainly the Elbe river in Germany, the Moldau and Elbe rivers in the Czech Republic and the Danube in Austria. More recently, a devastating flood affecting both the Elbe and the Danube occurred in June 2013. The largest economic damages occurred in Germany and Austria, with an estimate of over 1 billion euros and 870 million euros respectively (ICPDR, 2014).

The surge in the frequency of floods events and the increasing economic impacts associated with them, has been one of the factors which has prompted the European Commission to put forward the Directive 60/2007 (the 'Floods Directive') with the objective of reducing and managing the risks posed by floods to human lives, health and economies. The directive requires Member States (MS) to: a) carry preliminary risk assessment by 2011 and identify river basins and coastal areas at risk of floods; b) to elaborate detailed flood risk maps for the identified areas by 2013; c) to produce a comprehensive flood risk management plan (FRMP) by 2015. Although not explicitly mentioned in the 'Floods Directive', the concept of resilience is of relevance with respect to flood risk management. Because of the inherently dynamic nature of floods, the management of current and future risks is

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http://dx.doi.org/10.1016/j.envsci.2017.08.014
Received 22 November 2016; Received in revised form 8 July 2017; Accepted 15 August 2017

important to secure adaptation in the context of a changing climate (Priest et al., 2016).

Ecological resilience reflects the maximum shock a system can absorb without experiencing a regime shift (Folke, 2016; Walker et al., 2004; Holling 1973). This definition of resilience expressly acknowledges the possibility of multiple locally stable equilibria, novelty and change. For the purpose of this paper, it will be useful to refer to the concept of adaptive capacity when dealing with climate change adaptation. Adaptive capacity reflects the ability of a system to change and present innovative solutions in the face of disturbances (Armitage, 2005). Adaptation is a process of change in response to external stimuli and stress, while preserving the essential characteristics of a system (Nelson et al., 2007). In this sense adaptability crucially differs from transformability, whose emphasis is on creating new development pathways (for the system under consideration) in response to external shocks (Walker et al., 2009).

The objective of this paper is twofold. First, by relying on the existing literature, the paper describes the governance system associated with flood risk management in Austria prior to the elaboration of the FRMP. In this way, critical aspects are identified. Second, the paper assesses how the elaboration of the FRMP contributes to the adaptive capacity of Austrian institutions dealing with flood risk. To accomplish this second objective, first the FRMP is briefly presented in order to determine its influence on the flood risk management strategies. Subsequently, based on collected primary data, the governance structure associated with the elaboration of the FRMP in Austria is analyzed by using social network analysis (SNA). Although we acknowledge that the practical management strategies are important in determining the level of adaptability, in this article we focus our attention on the structure of the institutional network responsible for developing such strategies. The underlying hypothesis is that such a structure is also relevant in determining adaptive capacity (Carlsson and Sandström, 2008). Regarding the definition of governance, two aspects (as discussed by Stoker, 1998) are useful in the present context: a) governance refers to a set of institutions that go beyond government (thus including also non-governmental organization and eventually civil society); b) governance does not rest on the coercive powers of government, but sees the latter as capable of steering and guiding a process in order to achieve a desired common goal. Governance is thought of as a process, which is affected by the networks of political and social agents, in ways that can only be comprehended by analyzing the pattern of their relations (Christopoulos, 2017).

The rest of the paper is organized as follows. In the second section, the existing literature on adaptive capacity and network configurations of SES is briefly reviewed. In the third section, first a description of the Austrian governance structure up to the elaboration of the FRMP is presented, followed by a discussion on the main measures introduced by the FRMP and its incorporation into the Austrian flood risk management structure. In the fourth section, the methodological aspects of SNA and the data collection procedures are illustrated. In the fifth section, the empirical results are presented and discussed. In the last section, final conclusions are drawn.

2. Adaptive capacity and network configurations

The vast literature on governance networks and adaptive management of a coupled socio ecological system (SES) focuses on a number of network metrics like density, centrality, reachability, modularity, and cohesion (e.g., Chaffin et al., 2016; Valente, 2012; Sandström and Rova, 2009; Bodin et al., 2006; Janssen et al., 2006; Bodin and Norberg, 2005). For example, Sandström and Rova (2009) study the network structure of a fish management area in Sweden and report how the low degree of centrality negatively affects the ability to form rules, an important aspect in adaptive capacity. Chaffin et al. (2016), in the context of river basin management, report how increased density may indicate increased trust, increased communication sharing and possibly increased trust, all properties that correlate positively with the level of adaptive capacity.

In order to foster adaptive capacity, polycentric governance arrangements, structured around a number of different actors and institutions spanning across levels and connected through networks are necessary (Dietz et al., 2003). In particular, polycentricism allows for the redundancy necessary to buffer against unexpected changes (Huitelma et al., 2009). Governance structures should allow switching between two alternative modes (Folke et al., 2005): (1) maintaining the diversity necessary to prepare for change (e.g., favoring decentralization) and (2) promoting centralized coordination necessary to respond to changes. The configuration that best serves these purposes is one of a network partitioned in a number of modules (here generally defined as sub-parts of the whole network), to provide diversity (here generally defined as heterogeneity of actors, perspectives, resources); such modules should ideally be densely connected within and have a number of bridging ties connecting across, to provide coordination and promote collective action (Newman and Dale, 2005). Similarly, Carlsson and Sandström (2008) report that the network structure better equipped to ensure adaptability require both closure (i.e., density of within-group ties to ensure coordination) and heterogeneity (to ensure access to different resources). The literature reported here provides a backcloth against which our empirical results will be interpreted. We believe that three structural network aspects are particularly useful to assess the level of adaptive capacity in the present context, namely centrality, modularity and brokerage.

2.1. Centrality

Centrality measures refer to individual nodes. One of the most universal measures of centrality, betweenness, constitutes our measure of relative structural position. Betweenness "measures the number of times an actor is located on the path between two other actors in the network. Actors with high betweenness centrality could be brokers or entrepreneurs as they occupy a potentially privileged position in network structure" (: 494).

Another measure of centrality is indegree eigenvector centrality, which estimates centrality by weighting the relative centrality of all actors to whom the focal actor is connected to (Wasserman and Faust, 1994). It is in that respect a global centrality measure and provides an impression of the relative popularity of actors. In policy terms, it offers a good indication of those towards whom actors attempted to exercise influence.

2.2. Brokerage

A broker, in a network, is the actor who occupies a 'bridging' position, thus connecting otherwise unconnected actors. In order to analyze brokerage, we rely on Burt's measures of structural holes. Structural holes emerge when an actor's contacts are weakly connected between them, thus putting the actor in question in a brokerage position. These brokerage statistics offer an overview of the structural advantage or potential handicap from occupying specific network positions. The key statistics are effective size and constraint (Burt, 1992). The former is the number of alters, that an ego is directly connected to, minus a "redundancy" factor if those actors are already connected to one another (Burt, 2005). A high score implies an actor connects otherwise unconnected clusters and in its extreme score resembles a hub and spoke structure with ego being the hub.

Burt's constraint captures the degree to which an actor's network is "concentrated in one contact", the degree to which they are constrained and potentially exploited by brokers (Burt, 2005: 26). It can also be seen as the extent to which all of ego's relational investments directly or indirectly involve a single or few alters (ibid). The more constrained the actor, the fewer opportunities for action. Two other statistics include efficiency and hierarchy (see table S2 in SI for definitions). These metrics can be used to rank the relative importance of actors for brokerage of information or influence and in combination can help us determine their opportunities and constraints to action.

2.3. Modularity and clustering

Examining the modularity of a network can help us determine the degree to which clusters have formed or a core periphery has developed between key stakeholders. An overview of key statistics, based on a simple two-cluster partition, is provided here. Eta is a correlation coefficient between the actual network and an ideal one where ties are only allowed within clusters (Newman, 2010). Q is a modularity statistic devised by Newman and Girvan (2004) depicting the fraction of ties within a cluster partition minus the number that would be in the partition if ties were random, subdivided by the number of partitions. Q-prime is the normalized version of the same figure. This brings us to the next metric by examining more directly the possibility of the existence of a core-periphery with the E-I index devised by Krackhadt and Stern (1988), which considers ties within a partition as internal and calculates the difference of external to internal as a proportion of all ties.

3. Flood risk management in Austria

Due to its geographical situation, Austria has great familiarity with floods. Recent devastating events include the floods of 2002, 2005 and 2013. Because of its location in the Alpine arc (2/3 of Austrian territory is alpine), less than 40% of the territory is suitable for permanent settlement (and in Alpine areas less than 15% of the area is suitable for permanent settlement). In fact, river valleys and basins have always represented important settlement locations. Also because of its geographic location and climatic condition, Austria is rich in rivers and streams (over 100,000 Km of rivers and streams flow through Austria).

3.1. Flood risk management in Austria prior to the elaboration of the FRMP

Austria is a federal state divided into 9 regions (Länder): Burgenland, Carinthia, Lower Austria, Salzburg, Styria, Tirol, Upper Austria, Vienna and Vorarlberg. When it comes to natural hazards, legal and administrative competences are distributed across the federal, regional and local (municipalities) level on the basis of multiple regulations. At the federal level, for example, the effects of natural hazards are regulated by articles in the Austrian Forest Act, the Austrian Hydrography Act and the Disaster Fund Act. For example, in general, the management of waterbodies in Austria falls under the responsibility of the Federal Water Engineering Administration (Bundeswasserbauverwaltung, BWV, divided into 9 regional sections), while torrents control falls under the responsibility of the Forest Engineering Service on Torrent and Avalanche Control (Wildbach und Lawinenverbauung, WLV, divided into 7 regional sections). Both structures are embedded in the Federal Ministry of Agriculture and Environment (Bundesministerium für Land und Forstwirtschaft, Umwelt and Wasserwirtschaft, BMLFUW). The management of the rivers Danube, March and Thaya fall under the responsibility of the Federal Ministry of Transport (Bundesministerium für Verkeher, Innovation und Technologie, BMVIT). In particular, the public-owned company Via Donau is responsible for the maintenance and development of the Danube waterways (BMLFUW, 2006). The Federal Ministry of Internal Affairs (Bundesministerium für Inneres, BMI) plays an advisory role with respect to matters related to emergency and civil protection. At the regional level, spatial planning and land use regulations, laws regulating fire brigades and disaster aid are of paramount importance. Moreover, a number of agreements between regions and the federal administration, regarding financial compensation exist (Holub and Fuchs, 2009). Finally, local authorities and municipalities are responsible for spatial planning and land use management at the local level.

As noted by Thaler et al. (2016), the division of the administrative competences across various levels (federal, regional and local), reveals a critical aspect: the different legislative and administrative acts dealing with flood risk management were poorly harmonized across the regions and the federal government. To some extent, this is also due to the different topographies in the various regions. From an adaptive capacity perspective, the Austrian governance system prior to the elaboration of the FRMP, appeared extremely fragmented and in need of greater coordination.

3.2. Incorporation of the FRMP into the austrian flood risk management structure

The elaboration of FRMP in Austria is only one of the requirements stemming from the implementation of the EC 'Floods Directive'. Previous actions included the performance of comprehensive risk assessment (completed in 2011) and the production of detailed flood risk maps (completed in 2013). As a result of these exercises in Austria over 37,000 Km of rivers and streams have been surveyed (out of the total 100,000 Km existing) and 391 high risk flood zones have been identified (corresponding to 2650 Km).

The incorporation of the FRMP into the Austrian legal and administrative structure dealing with flood risk has been challenging, due to the already mentioned division of responsibilities between federal, regional and local level. Although the 'Floods Directive' has been formally transposed into the federal 'Water Law' most of the practical flood risk management measures follow from the spatial and emergency planning which is entirely under the competence of each region.

From the administrative point of view, the BMLFUW is ultimately responsible for the implementation of the 'Floods Directive' and thus the elaboration of a national FRMP. To this end the BMLFUW has facilitated the creation of a committee, formed by representatives of the key public administration actors mentioned above, with the task of discussing and elaborating the FRMP. The committee however can also consult stakeholders' external to the administration (e.g., non-governmental organizations like World Wildlife Fund; hydropower companies like Verbund AG) to inform some of its decisions. Following this process, a preliminary version of the plan has been circulated in the Spring 2015 for evaluation by the public and various stakeholder, before being finally approved (BMLFUW, 2016).

The plan provides a list of measures structured around the four phases of the flood risk cycle: prevention, protection, awareness, preparation and after-care. In terms of prevention, the most important measure pertains to the identification and subsequent actualization of risk zones, while in terms of protection the emphasis on non-structural measures and natural retention areas is increased. Awareness building becomes also important, through the dissemination of information and preparation relies mainly on the elaboration of forecasting models and the disaster management plans. It is important to stress that the regions have competence and are responsible for the implementation of all the measures in the plan, while BMLFUW acts as a coordinator. The plan also identifies the current implementation and/or development status of the measures and the foreseen status at future stages of the planning cycle (the 'Floods Directive' requires the FRMP to be reviewed in 2021 and subsequently every six years).

4. Methods and data

The objective of this study is to characterize the governance structure associated with the elaboration of the Austrian FRMP, in order to assess its contribution to the level of adaptive capacity of Austrian institutions dealing with flood risk.

4.1. Data collection

The consultation of official documents from the BMLFUW and the support of two experts at the European Commission Joint Research Centre (involved in the coordination of the European Flood Awareness System) allowed us to identify a preliminary set of key stakeholders, which included: the already mentioned federal actors (BMLFUW, BMVIT, BMI etc.), representatives from the International Commission for the Protection of the Danube River (ICPDR), hydropower companies, non-governmental organizations, institutions from regional governments. These actors were contacted in early May 2015 and interviewed between mid-May and early June 2015 (phase-I). The purpose of this first round of interviews was twofold: a) to obtain a better understanding of the Austrian flood risk management governance structure and b) to identify any additional stakeholders.

On the basis of the first round of interviews, we have set the upper boundaries of the study at the Austrian federal level (thus ignoring international actors) and the lower boundaries at the regional level (thus ignoring municipalities). These boundaries are appropriate to analyze the elaboration of the FRMP, which involves mainly regional and federal actors. Following the phase-I interviews, the ones responsible for flood risk management in each of the nine regions of Austria have been identified as important actors. A questionnaire, asking respondents to name those stakeholders which have collaborated to the drafting of the FRMP, has been developed. The purpose of the questionnaire was to detect the governance structure associated with the elaboration of the FRMP through a relational approach. The complete list of stakeholders (Supplementary information Table S1) were contacted in early June 2015 and a second round of interviews has taken place between mid-June and July 2015 (phase-II). Interviews with stakeholders operating at federal level were carried out in person, while those with regional players (with the exception of the actors in the regional/municipal administration of Vienna) were carried out on the phone. All the contacted stakeholders responded to the interview request, with the exception of the administration from Upper Austria. As a result, out of the 16 identified stakeholders, 15 were actually interviewed (denoting a 94% response rate).

4.2. SNA methodology

The use of SNA in order to study environmental governance has been increasing in recent years (e.g., Bodin et al., 2006; Jansen et al., 2006; Bodin and Crona, 2009; Chaffin et al., 2016). One of the advantages of using SNA lies in its ability to use well-defined metrics to characterize whole-network structures and actors' position, which have an impact on adaptive capacity. At the same time, it is essential to acknowledge that the use of quantitative metrics associated with SNA does not allow researchers to dispense from qualitative information. On the one hand, networks are constructed by researchers through the analysis of qualitative information (e.g., interviews). On the other hand, the SNA metrics lose most of their significance if they are not analyzed within a richer qualitative context. In the present context we use descriptive SNA, based on the reporting of frequency measures. The main advantage of this approach is that it allows to describe the exiting pattern of relations among actors in a way that can be easily integrated with the qualitative information contained in the interviews. At the same time, the descriptive approach adopted here cannot be used to perform inferential analysis.

As the policy in question was being developed while this research took place (2015), our analysis refers solely to the elaboration phase of the policy (thus ignoring the implementation and evaluation phases, yet to come). Nevertheless, we believe that the structural properties of the governance system associated to the elaboration phase of the FRMP contribute to the level of adaptive capacity (an important aspect of resilience) to one of the impacts of climate change (i.e., floods in this case).

The analysis presented here is based on interviewee answers to a name generator survey asking respondents to list other organizations they interacted with during the design phase of the FRMP (see SI). The information collected in the interviews is used to construct the network of their relations. Respondents were also asked to nominate others they deemed relevant beyond our key-stakeholder boundary. Our analysis and boundary frame was subsequently expanded to include two actors that have been mentioned more than twice (see bottom of Table S1). Analysis and graph representations employ the algorithms embedded in UCINET software (Borgatti et al., 2002). A general description of the metrics/statistics employed is provided in the Supplementary information (Table S2) to facilitate the interpretation of the results.

Although our stakeholders are organizations, the information has been collected through interviews with individual informants (affiliated to the respective institution). The issue of whether organizational ties can be captured through the ties of senior members of an organization is not new (e.g., Di Maggio, 1986). It is generally accepted that, when reflecting on their role within the organizational context, individuals respond in relation to actions of their organization (DiMaggio and Powell, 1983). We are confident of the quality of the data in the present study, since informants were selected for their prominence, seniority and knowledge of relations across this governance system.

5. Results and discussion

Overall, the average number of ties in our network (i.e., the network degree in SNA terminology) is 2.9, while overall density (i.e., the number of ties divided by the maximum possible number of ties for the considered network) is 0.173. Two indicative statistics of network structure are overall centralization and in-degree centralization. Centralization is a statistic describing the network as a whole, not to be confused with measures of centrality previously described. The score is a ratio of the observed to maximal, represented by a network with one actor connecting all others, who are not having ties among themselves (a hub and spoke graph). In our case, we obtain a centralization score of 0.202 and an in-degree centralization score of 0.564. The implication of this last statistic is that this network resembles to a good extend a hub and spoke structure, where many ties are directed to one key actor. A couple of measures indicating the "quality" of relations is arc reciprocity at 0.189 and transitivity at 0.491. These statistics indicate a low level of reciprocated ties and a fair level of transitive closure (i.e. friends of friends are also friends).

5.1. Centrality

When looking at betweenness centrality, the dominance of BMLFUW (1) is in ample evidence (Fig. 1). Further analysis will show (see subsection on brokerage) this actor to act indeed as the major broker in the network. As the specific question analyzed only reflects influence during a specific phase of the policy (i.e., design in our case), this dominance does not necessarily indicate a structural weakness. The most central actor here could act as a filter to demands, while a highly centralized network lacks resilience to disruption. In the present context, removing BMLFUW (1) could have significant consequences for the elaboration of the policy. Therefore, if the relations evident in this graph persist to the implementation or evaluation phase of the policy, this prominence could become problematic. The interviews revealed that the prominent role of BMLFUW (1) in this phase of the policy cycle reflects a preoccupation with achieving coordination and harmonization of the various regional measures (as embedded in the regional spatial and emerging planning laws) into a coherent national framework. On the other hand, given the Austrian administrative and legal structure previously described, the expectation is that during the implementation phase, agency will be much more diffuse.

Our heuristic understanding of structural adaptive capacity improves significantly once we consider a global measure of centrality,

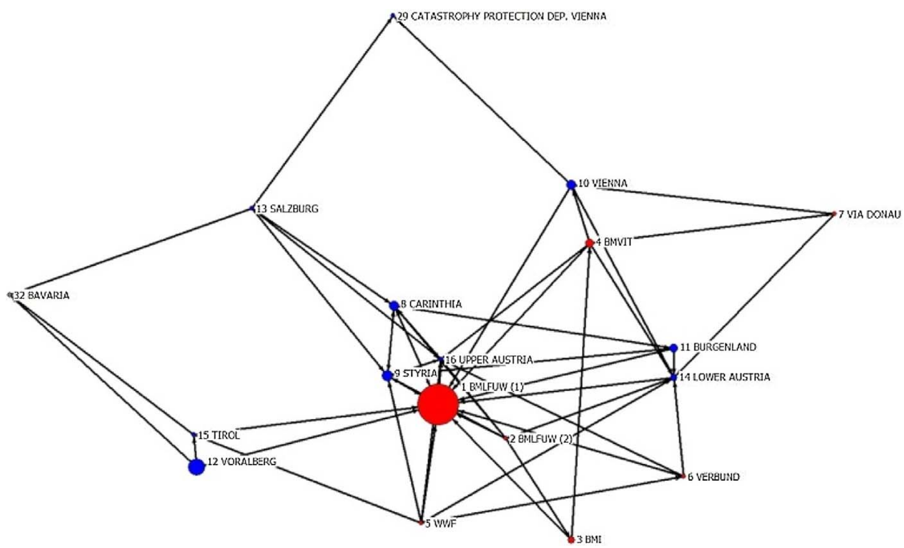

Fig. 1. Betweenness Centrality.
Note: Graph coloured by a hierarchical attribute (federal government red; Länder blue; foreign actors grey).

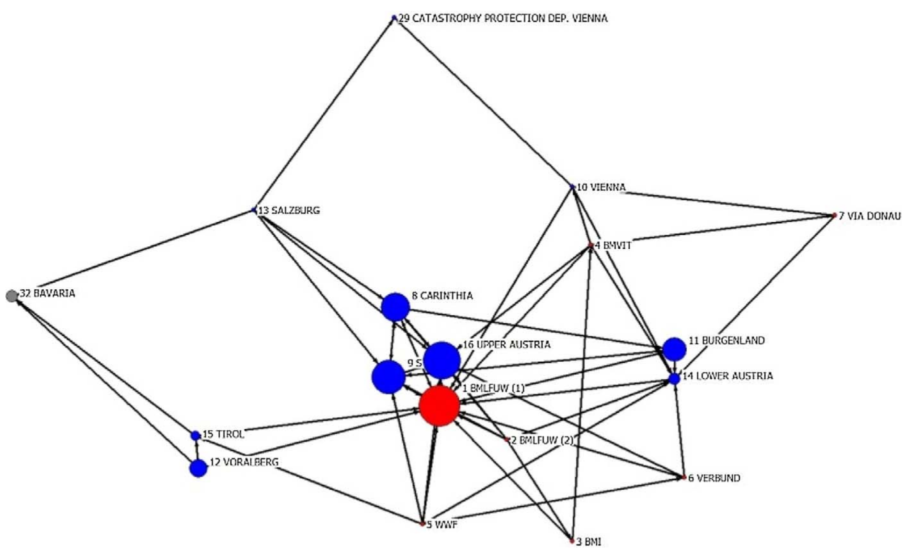

Fig. 2. Indegree Eigenvector Centrality.

indegree eigenvector centrality (Fig. 2). Upper Austria, Styria and Carinthia are equally influential as BMLFUW (1), while to a lesser extent Burgenland, Vorarlberg and Lower Austria are seen to be also prominent. Also of interest is the lack of prominence of actors who do not belong to the public administration, like WWF and the hydropower company Verbund. During the interviews, the former lamented having been excluded from the consultation phase that occurred in Tirol (a region to which WWF is particularly interested) between the regional government and the municipalities. Similarly, the latter actor also reported to have not played a significant part in the elaboration of the FRMP.

5.2. Brokerage

Regarding brokerage, we first present a graph (Fig. 3) of the reported interactions among the actors on the basis of Burt's (1992) effective size. It should be evident that: a) not all actors are equivalent in the structure of their transactions; b) that federal actors (denoted red) are clustered within a dense segment of the network (in the SE sector of the graph); c) that a number of regional actors, like Salzburg and the Catastrophe Protection Department of Vienna are not part of this core; d) while others like Carinthia, Burgenland and Vorarlberg are associated to it through the agency of BMLFUW (1). This implies a potential weakness in the ability of some actors to get their preferences on the agenda. In Table 1, the brokerage statistics associated with structural holes besides Burt's effective size are also reported.

Our analysis indicates that the highest brokers are BMLFUW (1), Upper Austria and Lower Austria. The actors with the highest constraint are Via Donau, Vorarlberg and the Catastrophe Protection Department of Vienna. During the interviews, all actors expressed very positive impressions about the existing mechanisms (both formal and informal) for information sharing. However, when looking at brokerage, the network data show a different picture. The implication is that one federal actor and two regions are instrumental in the dissemination of information, while a number of other key actors to flood planning depend on brokers for access to other key players of this policy ecosystem. This is particularly evident for Via Donau, Vorarlberg and the Catastrophe Protection Department of Vienna, but also for Burgenland and Tirol. The interviews reveal that Via Donau is mainly involved in the management of structural flood protection measures (e.g., existing dams) rather than in the formulation of the flood protection measures; while Voralberg involvement, at the political level, has occurred mainly in terms of communications with local political leaders (e.g., mayors of various municipalities in the region). The brokerage analysis shows that all these actors are only able to access information through the mediation of one of the three brokers mentioned earlier. The relevance of

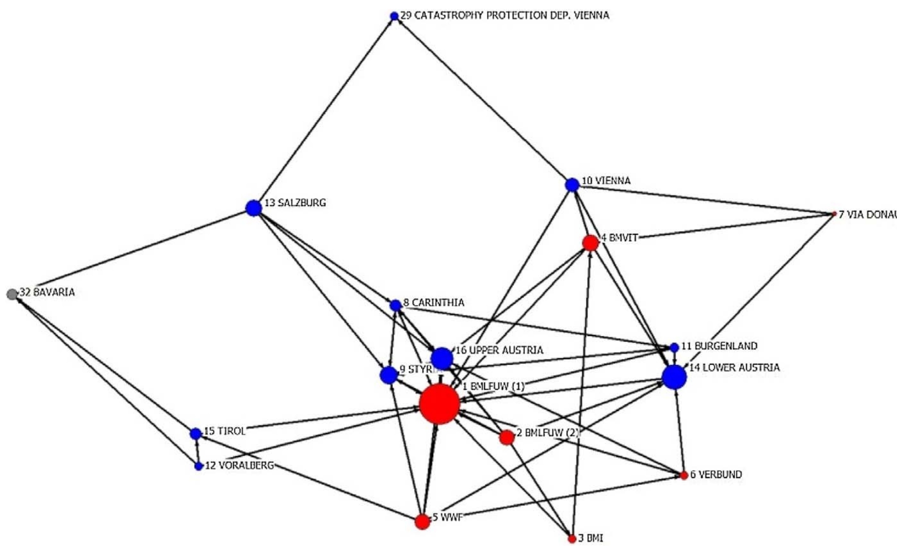

Fig. 3. Effective Size Brokerage.
Note: Graph coloured by a hierarchical attribute (federal government red; Länder blue; foreign actors grey).

Table 1
Burt's measures of structural holes.

Actor #	Institution	Effective Size	Efficiency	Constraint	Hierarchy
1	BMLFUW (1)	9.69	0.75	0.22	0.06
2	BMLFUW (2)	3.75	0.63	0.34	0.06
3	BMI	2.00	0.67	0.45	0.02
4	BMVIT	4.00	0.67	0.33	0.04
5	WWF	3.75	0.63	0.33	0.04
6	VERBUND	1.88	0.47	0.42	0.01
7	VIA DONAU	1.00	0.33	0.59	0.00
8	Carinthia	2.88	0.48	0.43	0.13
9	Styria	4.10	0.59	0.36	0.13
10	Vienna	3.20	0.64	0.36	0.03
11	Burgenland	2.10	0.53	0.49	0.10
12	Vorarlberg	1.88	0.63	0.55	0.12
13	Salzburg	4.00	0.80	0.29	0.02
14	Lower Austria	5.94	0.74	0.27	0.05
15	Tirol	2.75	0.69	0.47	0.04
16	Upper Austria	5.31	0.66	0.30	0.06
29	Catastrophe Prot. Dep. Vienna	2.00	1.00	0.50	0.00
32	Bavaria	2.50	0.83	0.46	0.02

this finding of course depends on the degree to which these ties have permanence and these actors are able to bridge these structural holes (Burt, 2005) by sidestepping brokers. These stakeholders lack a comprehensive mental map, and therefore accurate cognitive representation of these structural holes. The implication is that from the vantage of each individual actor potential information bottlenecks are not always apparent.

5.3. Modularity & clustering

The results for modularity are presented in Table 2. The low value of eta observed (0.009) indicates this network is not clustered into "silos". The Q-prime value also indicates moderate levels of modularity (0.212). The negative value of the E-I index indicates more internal than external ties and reflects the existence of a weak core-periphery structure.

Table 2
Modularity Statistics.

	Eta	Q	Q prime	E-I
Partition	0.009	0.106	0.212	−0.17

Table 3
Factions Block Assignments & Density Table: the bottom of the table reports the density of ties sent from the row-group to the column-group.

Groups	Actors		
Group 1	1, 2, 8, 9, 11, 13, 16		
Group 2	3, 4, 7, 10, 14, 29		
Group 3	5, 6, 12, 15, 32		
Density	Group 1	Group 2	Group 3
Group 1	0.48	0.10	0.06
Group 2	0.12	0.27	0.00
Group 3	0.20	0.07	0.25

With respect to clustering, the two-faction solution achieves an efficiency of 60%, while the three-faction solution an efficiency of 74% and is reported below in Table 3. A density table offers an overview of within and between group ties. Group 1 constitutes the core, where a relatively large of within-group interactions occur (as shown in Table 3), with key actors being BMLFUW (1), BMLFUW (2), Carinthia, Styria, Burgenland, Salzburg and Upper Austria. Largely, these actors represent those that appear to be more influential (as already noted when discussing indegree eigenvector centrality) to the formation of the policy. Group 2 and group 3, on the other hand, appear less important in terms of within-group interactions. In Table 3 we also observe that group 3 appears strongly peripheral to group 1 with a 0.2 density of ties sent, that are unequally reciprocated with a 0.06 density of ties received from group 1.

To sum up, we observe a network configuration with low modularity and with a weak core-periphery structure arranged mainly around BMLFUW (1). This is confirmed by the analysis in terms of modularity, where a set of actors (namely BMLFUW (1), BMLFUW(2), Carinthia, Styria, Burgenland, Salzburg and Upper Austria) appear to form part of a core.

6. Conclusions

Flood events have been increasing in frequency and intensity in Europe over the last decades (Barredo, 2007), a fact which has prompted the EU to adopt the 'Floods Directive'. Resilience and adaptive capacity remain essential aspects of flood risk management, within an adaptation strategy to the changing climate. In turn, the structure of the institutional network responsible for the elaboration of environmental risk management strategies (including flood risk management strategies) is also important for determining the level of adaptability.

The governance system for the management of flood risk in Austria, prior to the elaboration of the FRMP, appeared to be fragmented, mainly because of the Austrian federal structure. Our stakeholders confirmed this during the interviews. BMLFUW (2), for example, explicitly mentioned the lack of coordination between two important regions as one of the causes for the high impact of the 2002 flood event. At the same time, most of the interviewed actors claimed that the main challenge encountered in elaborating the FRMP in Austria was the coordination of the various regions (who may have different priorities due, for example, to different topographical configurations) among themselves and with the federal government. On the one hand, the elaboration of the FRMP has certainly facilitated the organization of the various FRM measures (as embedded in the nine regional spatial and emergency planning regulations) into a coherent national framework, thus improving inter-regional coordination and the overall level of adaptive capacity.

On the other hand, SNA reveals the governance structure associated with the elaboration of the Austrian FRMP to be highly centralized and dependent on a small number of hub actors. This is immediately obvious by looking at the two measures of centrality presented, where BMLFUW (1) is clearly dominant. The network also exhibits a low degree of modularity, mainly centered on BMLFUW (1). The same actor also appears to be one of the most effective brokers, alongside other regional actors (e.g., Lower Austria and Upper Austria).

However, as noted by Andersson and Ostrom (2008) and Ostrom (2010), the ability to adaptively manage natural resources significantly improves when multiple organizations (including NGOs and private companies) at multiple levels are part of the governance system. Including a broader set of actors (beyond public administration) helps to incorporate a wider knowledge (e.g., Berkes and Folke, 2002) and/or may facilitate the implementation phase by reducing possible conflicts (Newig et al., 2005). The network analysis and the interviews suggest that a number of important actors, like WWF, Via Donau, the hydropower company Verbund, some regional administrations like Voralberg and Vienna remain marginal to the elaboration of the FRMP. Following the idea of network interventions (Valente, 2012) we advocate measures to improve the structural position of the actors mentioned. This could be achieved by presenting all the actors with brokerage and centrality statistics discussed in this paper (e.g., effective size and constraint) in order to foster purposeful rewiring of the network. By improving the number of bridging ties, this type of interventions could contribute to adaptability. The incorporation of a wider set of organizations (beyond pubic administration) in the earlier phases of the policy cycle, is therefore welcomed not only make the whole process less technocratic, but also to effectively improve the overall level of adaptive capacity.

Acknowledgments

The research carried out in this article was supported by the EC Joint Research Centre, Ispra, Italy. The authors would like to thank two anonymous reviewers for their comments, which allowed to improve the manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2017.08.014.

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