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Evaluating learning spaces in flood risk management in Germany: Lessons for governance research

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Abstract

Efforts to collaboratively manage the risk of flooding are ultimately based on individuals learning about risks, the decision process, and the effectiveness of decisions made in prior situations. This article argues that much can be learned about a governance setting by explicitly evaluating the relationships through which influential individuals and their immediate contacts receive and send information to one another. We define these individuals as "brokers," and the networks that emerge from their interactions as "learning spaces." The aim of this article is to develop strategies to identify and evaluate the properties of a broker's learning space that are indicative of a collaborative flood risk management arrangement. The first part of this article introduces a set of indicators, and presents strategies to employ this list so as to systematically identify brokers, and compare their learning spaces. The second part outlines the lessons from an evaluation that explored cases in two distinct flood risk management settings in Germany. The results show differences in the observed brokers' learning spaces. The contacts and interactions of the broker in Baden-Württemberg imply a collaborative setting. In contrast, learning space of the broker in North Rhine-Westphalia lacks the same level of diversity and polycentricity.

KEYWORDS

brokerage, collaborative water governance, comanagement, comparative analysis, social networks

1 | INTRODUCTION

While personal experiences matter in flood risk management, it is a person's social contacts that determine the feedback that an individual receives and learns from (Albright & Crow, 2014; Pahl-Wostl, 2006, 2009). Liefferink, Wiering, Crabbé, and Hegger (2018) caution that these social networks can grow into complex and entangled governance system that can drive (Kaufmann, Mees, Liefferink, & Crabbé, 2016) or hinder (Matczak, Lewandowski, Choryn ski, Szwed, & Kundzewicz, 2018) intentional efforts to reform flood risk governance. The dominant view in the current discourse is that frequent and reciprocated interactions between a diverse set of actors that represent all vested interests in specific policy solutions are resource intensive (Emerson & Nabatchi, 2015a, 2015b; Matczak et al., 2018), but can function as drivers of learning, and of subsequent policies and practices to effectively manage complex issues, such as the risk of flooding (Ansell & Gash, 2008; Emerson, Nabatchi, & Balogh, 2012; Voorberg, Bekkers, Timeus, Tonurist, & Tummers, 2017; Voorberg, Bekkers, & Tummers, 2015). Settings that allow for these interactions can be defined as collaborative, or participatory, governance arrangements for the management of flood risk.

While the notion of governance has become an integral part of flood risk management (Driessen, Dieperink, van Laerhoven, Runhaar, & Vermeulen, 2012; Lange, Driessen, Sauer, Bornemann, & Burger, 2013), collaborative governance is a fairly new concept (see, for example, Challies, Newig, Kochskämper, Thaler, & Levin-Keitel, 2016). The term describes "a group of autonomous stakeholders of a problem domain who engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain" (Wood & Gray, 1991). According to the literature, the aim of a collaborative governance arrangement is to develop legitimate solutions to complex problems by ensuring that all the actors at the table not only hear but also understand each other well enough to learn from one another (Ansell & Gash, 2008; Emerson & Nabatchi, 2015a, 2015b). In order for this learning to take place, collaborative governance arrangements include all vested interests in the deliberation (Ansell & Gash, 2008; Heikkila & Gerlak, 2015). This is a particularly sensitive topic in flood risk management since various actors are directly affected by the risks floods pose to cultural and economic assets, as well as to people (Eisenack et al., 2014; Newig, Challies, Jager, & Kochskämper, 2014).

In the German context of flood risk governance, participation is established through the requirements of the EU Floods Directive. Currently, the participatory experiences of German federal states are considerably varied since the directive allows for a lot of leeway regarding the establishment of processes (Newig et al., 2014; Newig, Kochskämper, Challies, & Jager, 2016). Nonstate actors, particularly those from civil society, are not frequently involved in these participatory arrangements (Newig et al., 2014). Additionally, certain areas of focus, such as floods caused by heavy rain, are not tackled by the directive. This is not necessarily a German phenomenon. For example, Canadian scholars also observe the governance of flood risk management to be less successful in unregulated policy contexts (Henstra, Thistlethwaite, & Vanhooren, 2020; Thistlethwaite, Henstra, & McBean, 2019).

In a fairly unregulated policy domain, individuals in brokerage positions are expected to drive the exchange of information, and hence the development of a collaborative arrangement (Ansell & Gash, 2008). This kind of leadership can catalyze a group to work together, protect the integrity of the collaboration process, and mediate conflicts between stakeholders (Ulibarri et al., 2020). The governance of policy concerning floods caused by heavy rains can therefore be seen as relying on *brokers* to establish, legitimize and guide interactive processes. It is through frequent and reciprocated interactions between actors with different interests that individuals in a formal, or informal, collaboration can learn about knowledge gaps and the available strategies for responding to complex issues (Emerson & Nabatchi, 2015a; Pahl-Wostl, 2006, 2009; Reed, 2008). Hence, the relationships through which a broker sends and receives information might constitute necessary conditions for the emergence of collaborative governance arrangements in flood risk management. For simplicity, we define this network of interactions, here, as a broker's *learning space*. This gives rise to the following questions: "What can analyzing brokers' learning spaces tell us about the nature of governance arrangements in fairly unregulated policy domains?" and "Do brokers drive their learning spaces toward collaborative arrangements for improved information flow?."

Despite its significance, we know little about a broker's *learning space*. Research on brokerage in policy processes tends to focus on the actors brokers connect to one another (see, e.g., Ingold & Varone, 2011) or attributes of the broker. The aim of the research presented in this article is to address this gap by introducing an approach with the intent of capturing generalizable data about the members of a broker's learning space and their interactions. Knowing these properties of a broker's learning space allows us to make deductions about the nature of governance arrangements in flood risk management without having to fully survey all its members. After all, brokerage activities are credited with the emergence of such collaborations in poorly regulated (Ansell & Gash, 2008) and/or highly adversarial settings (Carmin & Anguelovski, 2012), such as flood risk management.

Utilizing theoretical insights into collaborative, or participatory, water and flood risk governance, we first develop a list of the properties of a broker's learning space that are indicative of specific properties of a collaborative governance arrangement. Next, we introduce a methodological framework that captures these indicators. Then, we demonstrate the framework's potential with a comparison of two cases in the context of urban flood risk management in Germany. Each case constitutes an analysis of the properties of a broker's learning space. The key insights from this comparison and the lessons from this study are summarized in our conclusion.

2 | PROPERTIES OF A BROKER'S LEARNING SPACE THAT ARE INDICATIVE OF COLLABORATIVE GOVERNANCE

The literature on collaborative and participatory governance abounds, and there are various pillars which are thought to be constitutive of respective arrangements (see, for example, Emerson & Nabatchi, 2015a, 2015b; Newig, Challies, Jager, Kochskämper, & Adzersen, 2018). In the following, we draw on the three main elements of diversity in representation, balanced power, and interactive dialogue, as well as on the related concept of polycentricity. Starting with the latter, polycentricity, which means having several independent, but interacting decision centers that structure and order governance arrangements (Ostrom, 1990; Skelcher, 2005), is seen as vital for acting on and making decisions about problem domains in an interactive way. Polycentric governance structures are seen as better equipped than hierarchic structures to deal with uncertain and complex problems in a flexible way that allows for learning (Huitema et al., 2009; Ostrom, 2005), and are therefore particularly recommended in collaborative water governance (Thiel, Blomquist, & Garrick, 2019). However, scholars also caution that the management of this complexity is resource intensive, which not always results in positive outcomes (Matczak et al., 2018). The adaptability to new environmental challenges depends on the ability of individuals in a collaborative governance arrangement to communicate decisions and observations across centers of decision-making (Andersson & Ostrom, 2008; Pahl-Wostl, 2006, 2009; Schneider, Scholz, Lubell, Mindruta, & Edwardsen, 2003; Weiss, Hamann, Kinney, & Marsh, 2012). Therefore, and since flood risk management is usually a shared municipal responsibility distributed among authorities of different governance levels, polycentricity, allows brokers to mediate information flow across these diverse centers of decision-making. Consequently, brokers' learning spaces should include representatives from all administrative levels that can influence governance decisions.

Indicator 1. Learning spaces that include representatives from all the relevant administrative levels are indicative of polycentricity in a collaborative governance arrangement.

Turning now to the essentials of collaborative governance, the first cornerstone is diversity: A balanced representation of all stakeholders who could be affected by or have a vested interest in the issue increases the legitimacy of a collaborative governance arrangement (Ansell & Gash, 2008; Emerson et al., 2012; Heikkila & Gerlak, 2015; Johnston, Hicks, Nan, & Auer, 2011; Pells, 2015; Vangen, Hayes, & Cornforth, 2015). The diversity of the represented interests ensures that all stakeholders who can impact an outcome are aware of the issue (Woldesenbet, 2018). Further, diversity is seen as boosting learning by providing for different points of view and knowledge types (Heikkila & Gerlak, 2015), which in turn should therefore be seen as an important characteristic of a broker's learning space within a collaborative governance arrangement.

Indicator 2. Diversity of represented interests in a broker's network is indicative that a collaborative governance arrangement complies with a balanced representation of all relevant stakeholders.

If collaborations are to build their capacity for learning, they rely on all the stakeholders to be able to send and receive feedback (Ansell & Gash, 2008; Berkes, 2009; Dalton, 2006; Newig et al., 2016; Reed, 2008; Woldesenbet, 2018). Through interactive dialogue and communication, trust can be built, mutual learning and orientation toward the common good can emerge, and mutual gains can be identified; all of these factors are assumed to lead to effective decision-making (Newig et al., 2018). The efficacy of these factors also applies to participatory water and flood risk governance (Challies et al., 2016; Newig et al., 2016). These dynamics are supposed to intensify over time, requiring an interaction of stakeholders that goes well beyond a one-time experience (Emerson & Nabatchi, 2015a, 2015b). Hence, we expect a high proportion of frequent interactions in a broker's learning space, here defined as strong relationships.

Indicator 3. Learning spaces that include proportionally high numbers of strong relationships are indicative of civil, two-way dialogues between individuals in a collaborative governance arrangement.

Renn (2006) argues that collaborations must design mechanisms that go beyond intention, and actually enable the incorporation of expertise, as well as different interests and values. Pita et al. also highlights variations in the perceived levels of participation, ranging from passive (informed) participation, to functional participation (stakeholders are actually involved). In theory, successful collaborations also actively employ measures to empower disadvantaged stakeholders, and subsequently ensure that all the interests are sufficiently represented in the interactive process (Ansell & Gash, 2008). To accomplish this, power imbalances need to be avoided during the deliberation, during which information is shared among the diverse stakeholders (Ansell & Gash, 2008; Heikkila & Gerlak, 2015; Johnston et al., 2011; Renn, 2006). We therefore propose that a broker's learning space consists of a network with many relations between a diverse set of actors, in which information flow is decentralized. In other words, information does not flow solely through the broker, but freely in their networks.

Indicator 4. Learning spaces that are dense, with low levels of centralization are indicative of balanced power within a collaborative governance arrangement that no one dominates.

The hypothetical case that is shown in Figure 1 represents a learning space from which a collaborative governance arrangement is expected to emerge. It shows a small group of stakeholders with distinct interests, most of whom maintain strong relationships. A municipal actor occupies the brokerage position. She maintains dialogical interactions with three other actors, who each represent one of three hypothetical different interests. She also includes in the deliberation actors from the relevant decision centers. Most importantly, all the actors in her learning space are connected to one another. This way, no one actor or small group of actors controls the interactions in a collaboration. To sum up, four properties characterize the ideal learning space for a broker who seeks to facilitate a collaboration in flood risk management: polycentricity, diversity, strong relationships, and high density of interactions.

3 | RESEARCH DESIGN AND METHODS

In order to uncover the characteristics of a broker's learning space, we opted for a generalizable survey design that relates the survey participants (here referred to as "Ego") to their contacts (here referred to as "Alter") (Borgatti, Everett, & Johnsonm, 2018). We asked the survey participants to indicate with whom they were in contact (name generator), how frequent these contacts were (name interpreter), and how they perceived the relations between their contacts (alter-alter-matrix). In addition, attributional data were collected for all Egos and Alters. In this context we also tested the web interface we developed especially for this purpose, which was created using EgoWeb 2.0 (Witting, Brandenstein, & Satoh, 2020). In a second step, survey participants were invited to take part in a 90-min conversation with the researchers. By means of a participatory procedure, missing connections in the network were uncovered, and the preliminary analysis results are supplemented.

3.1 | Measurements

Ego-centered network analysis, as applied here, examines the social environment from the perspective of individuals. Social network analysis, of which Ego-centered analysis is a part of, maps network relations in various ways and applies a formal methodology to analyze these relations (Witting, Brandenstein, & Satoh, 2020). It offers a rich toolset to systematically analyze a broker's learning space (Witting, Brandenstein, & Satoh, 2020), which is defined here in terms of the Alter(s) and their information exchange with the broker (Ego), but also in terms of the Alters' relationships with one another. We did not capture whether information was flowing in both directions (depicting mutuality), and therefore chose to present the data case as an undirected network graph. Additionally, we employed more detailed measures to describe each of the four properties that we expected in a broker's learning space. Table 1 summarizes these measures. A detailed outline is provided in the Appendix.

3.2 | Study areas

Our analysis draws cases from flood risk management arrangements that are currently engaged in efforts to establish collaborations to tackle mostly unregulated problem domains, in particular, the contribution of heavy rain and/or sediment to flooding. We explicitly explore

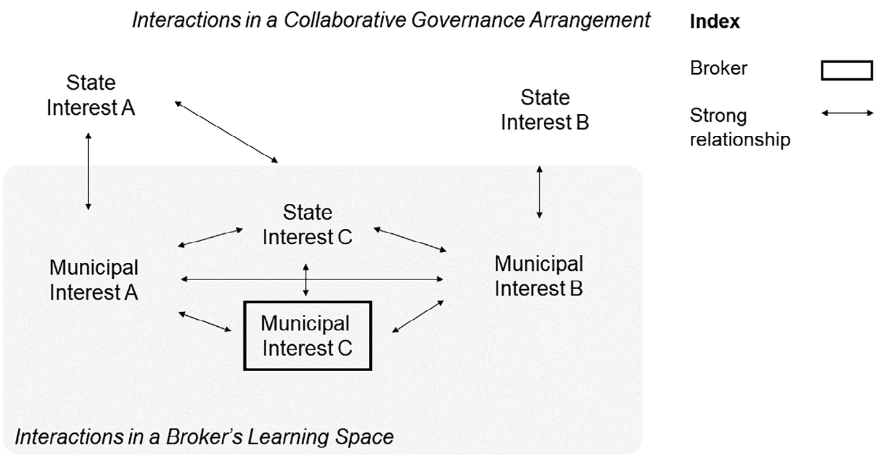

FIGURE 1 Hypothetical example of a learning space in a collaborative governance arrangement

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TABLE 1 Measurement (see Appendix for a detailed description)

Brokers' learning space properties	Measurement
Indicator 1: Polycentricity reflected in the broker's learning space	Count all instances in which three individuals are directly connected to one another (triads) connecting at least two of the three centers of decision-making (municipal, state)
Indicator 2: Diversity of the represented interests in the broker's learning space	Count all triads connecting at least two of the three sectors (public, private, nongovernmental)
Indicator 3: Learning spaces that include proportionally high numbers of strong relationships	Proportion of strong intersectoral, interlevel (combined = intergroup) ties (information exchange 1–3 week, month, year, since last event, one-time occasion)
Indicator 4: Learning spaces that are dense with low levels of centralization	Centralization (betweenness, degree)

broker networks in two arrangements that address very distinct risks, to ensure that our observations are not specific to the problem domain. Each broker network constitutes a case. Both cases are drawn from settings in Germany. From the available evidence we learn that heavy rains primarily pose a threat to communities in the South and West of Germany (Brasseur, Jacob, & Schuck-Zller, 2017; Climate Service Center, 2015; KLIWA, 2006), in particular, when their vulnerabilities are left unaddressed (Deister et al., 2016; URBAS, 2008). Hence, municipalities in the at-risk regions are taking steps to bridge legislative gaps and address their vulnerabilities to these hazards through informal collaborations that may or may not be institutionalized over time (Reese, 2011). Bund-/Länderarbeitsgemeinschaft Wasser (LAWA), the federal advisory body on flooding, recommends that an intensive exchange must occur between all actors involved in flood risk management arrangements (e.g., political agencies, forestry and agricultural specialist, planners, affected citizens, and rescue and emergency services for disaster control), and that there be close coordination within the administration between the various municipal specialist offices (e.g., those governing planning, road construction, environmental affairs, drainage, and public order). Exchange is also required to prevent potential conflicts between the actors (LAWA, 2018).

The first case is drawn from a flood risk management arrangement that tackles the risk of heavy rain for the highly urbanized Emscher-Lippe region in the state of North Rhine–Westphalia (NRW) in western Germany. Our second case is based in the southwest of Germany, in the state of Baden-Württemberg (BW) that is currently seeking to adapt their arrangement to account for the risk of sediment movement in relation to flash floods. In each case, individuals join forces to collectively manage the risk of flooding.

3.3 | Sampling strategy

The available evidence suggests that multiple individuals in a collaboration can occupy brokerage positions (Ulibarri et al., 2020). In order to systematically identify brokers in the study areas, we used a respondents-driven sampling method (Heckathorn, 1997). The method differs from classical snowball sampling in that the first wave of respondents directly recruits more respondents. This way, each new wave of respondents can remain antonymous throughout the process. This sampling approach results in a first order Markov chain (Heckathorn, 1997). For the first survey wave (the survey seeds) we asked the press office of the city administration being investigated: "Who in your administration is working on the follow-up of urban floods?" We decided to use the press office as a starting point in order to avoid the assumption that specific departments should lead communication on flood risks. It was also a useful approach to gain initial insights into the municipal communication structures in this particular problem area.

4 | FINDINGS

The remainder of this article summarizes our observations of the two cases that we selected for this study (see above for sampling strategy). To protect the identity of the individuals who are being observed, we obscure details that would lead back to them. Before introducing each case, we will first outline the available secondary information about the risks and the arrangement that was formed in response.

4.1 | Case I Governance of urban flood hazards in NRW

In 2014, a heavy rainfall event in the city of Münster in the German state of NRW caused significant damages, even though standard measures of risk, and contingency management had been in place. Combined with the evidence of exceptionally heavy rains being on the rise, the state recognized the need to assess the risks that underlie the flood hazard, and implement adaptation measures in state master plans and subsequent regulations (NRW, 2016). At that point, flood risk management only partially addressed these incidents, mainly because it focused on flood events springing from watersheds. This becomes particularly clear in the Emscher-Lippe region, a densely populated catchment area of the Emscher and Lippe rivers. The fact that these rivers and their tributaries do not overflow their banks is ensured, among other things, by huge pumping stations and generously dimensioned storage channels with throttled outflows, which can either discharge large amounts of water, or temporarily store them. This approach to flood risk management is costly because the diameter of the pipes has to be adjusted to meet an ever-increasing demand for more capacity (NRW, 2016). This demand is increasing as systems struggle to cope with the combined effects of urbanization and climate change.

Considering these developments, the municipalities of the Emscher-Lippe region, the Emschergenossenschaft—a semipublic entity that manages flood risk in the region—and the state of NRW signed a declaration of intent for the future initiative, “Water in the City of Tomorrow,” in May 2014. The involved municipalities and the Emschergenossenschaft are committed to taking steps to shift flood risk management from channeling water into the sewage system, toward draining it through installations in open spaces, such as meadows or sports fields. In addition, more water surfaces are to be created, and urban areas unsealed. Several rainwater retention basins will also be built. These measures aim to prevent damages that arise when roads, and subsequently, basements are flooded. In short, the collaboration intends to better respond to common challenges posed by heavy rains.

Between September and November 2018, we approached brokers in cities with 250,000 or more inhabitants in the Emscher-Lippe region. Contact was first established via the cities' press offices. We asked them to establish a link to the person/people who would usually lead the evaluation of flood events in their municipality. With the exception of Duisburg, all press offices identified brokers and successfully mediated our contact. In Gelsenkirchen, Essen and Dortmund, samples were identified for the first survey wave. In all cases, the survey was concluded with the first wave, as the respondents stated that, counting them and their contacts, all important brokers in the city's heavy rain risk management were recorded. Three respondents expressed interest in participating. Two cancelled at short notice. In this context, the survey data could only be verified for one municipal broker. This broker occupies a formal position that requires the position holder to coordinate information flow in their municipality.

4.1.1 | Analysis: NRW

Figure 2 provides a visual summary of the verified data for this broker. With all the broker's contacts operating at the municipal level and being part of the public sector, and none of them from private or nongovernmental organizations, the network shows no diversity or polycentricity. A comparison with the maximum diversity possible, as outlined in the Appendix, is therefore superfluous.

Likewise, the data did not allow an analysis of the strength of the relationships that link the different sectors (cross-sector relationships) and levels (interlevel relationships).

The centralization scores for the network are fairly low (0.21 for betweenness,[1] and 0.5 for degree [see Appendix for a more detailed description]). These values are also reflected in the graphical representation of the network (see Figure 2). All nodes in Figure 2 have short paths to reach each other and where—in case an edge would be blocked—short alternatives to pass information could easily be found.

In conclusion, we are only able to confirm that the broker's network complies with the notions of fair and civic discourse and power balance. The absence of polycentricity and diversity implies little to no cross-boundary

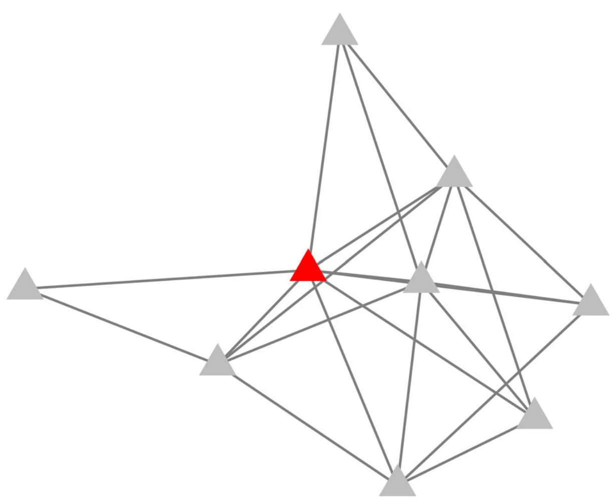

FIGURE 2 Learning space for Case I. Node shapes: triangles (public sector). Node color:red (Ego), gray (Alter). Link type: solid (convergent interlevel relationship). Link strength: increases with strength of the link connecting any two nodes

information flow. Both diversity and polycentricity can only be expanded by adding new actors to the network.

4.2 | Case II Governing flash flood hazards in BW

Climate change has also increased the risk of extreme rain events occurring in BW (Brasseur et al., 2017). Major damage is expected from surface runoff coming from heavy rainfall and the combination of river water with surface water in densely populated areas. In mountainous regions such as the state of BW, this is aggravated by the risks of erosion, bedload, and driftwood, which can lead to higher damage. BW has already established a well-integrated flood risk governance arrangement that accounts for bottom-up coordination with municipalities in cross-municipal partnerships—so-called flood partnerships—that also include the participation of additional stakeholders and interested citizens (Newig et al., 2014; Witting, Brandenstein, Zarfl, & Lucía, 2020). Flood partnerships have existed since the 1990s in response to major floods in the area, long before the implementation of the EU Floods Directive of 2007. Their structure and tasks were adapted to align with the integrated and participatory vision of the directive. Additionally, in accordance with the guideline, "Flood risk and strategies for damage mitigation in BW" (UM, 2014), and particularly, the "Guidelines for Municipal Heavy Rain Risk Management in BW" (LUBW, 2016), the state supports municipal heavy rain risk management via governance districts, among other channels, which further support the coordination between state authorities and local water authorities, as well as municipalities. These documents include three building blocks for a flood risk management plan: (a) heavy rain hazard maps, (b) risk analysis, and (c) action plans. Flood hazard maps for the regions with significant flood risk are embedded in the water law of BW. This legal basis also forms the basis for cooperation with local authorities until the flood hazard maps have been completed. This arrangement is far from static.

Although the flood risk governance arrangement concerning fluvial floods is rather advanced in BW (LUBW, 2016; UM, 2014), the planning structures for heavy rain are only just emerging and are much more reliant on action by municipalities and urban areas; our case study here is a demonstrative example. Initiated by the observed broker and under the direction of the Executive Board of the city of Stuttgart (Ref. 53.2), a specialist group was founded after a severe flash flood in order to foment collaboration between colleagues at the state level, local decision makers and experts, to determine the dangers of heavy rain and bedload for municipalities (Witting, Brandenstein, Zarfl, & Lucía, 2020). The group's goal is to use this event as a template to improve flood risk mapping.

Upon inquiry, we were directed to a state-level broker, who directed us to 11 individuals who occupy various brokerage positions, serving, for example, to connect the municipal with the state level, and were therefore invited to participate in the survey. All the individuals accepted the invitation. Four survey participants also verified their survey data. In this article, we only present the analysis of the one municipal broker in this second case study, since we also examine a municipal broker's network in our first case study, above. Likewise, this broker maintains a formal position that requires the position holder to coordinate information flow in their municipality.

4.2.1 | Analysis: BW

Figure 3 gives an initial analysis of the findings of our second case study, showing a fairly densely connected network. However, when compared to Figure 2, there are nodes less well connected to the core of the network. Potentially, information reaching them could be filtered by brokering nodes on the path to the network's core. The different shapes and line styles represent the larger diversity and polycentric character of the network. For a more extensive analysis of the network, we apply the measures described in Table 1 to assess diversity and polycentricity. Defining diverse triads as those connecting nodes from at least two of the three different sectors, the maximum number of theoretically possible diverse triads is 208. The number of polycentric triads—those connecting the two levels of state and municipality—cannot exceed 180. A total of 161 diverse and 112 polycentric triads are observed (77 and 62% of the maximum, respectively).

Having assigned link-strength values based on interaction frequency we can also examine the strength of the relationships in the broker's learning space.[2] Table 2 shows that the cumulative strength of all the relationships in the network (950) is quite evenly split across polycentric and nonpolycentric triads (536–414). In contrast, intersector relationships are notably stronger than relationships between actors that represent the same sector.

The scores of the standard centralization measures applied here are relatively low (betweenness: 0.4, degree: 0.47).[3]

Taken as a whole, the analysis suggests that the broker's learning space represents diverse interests, and

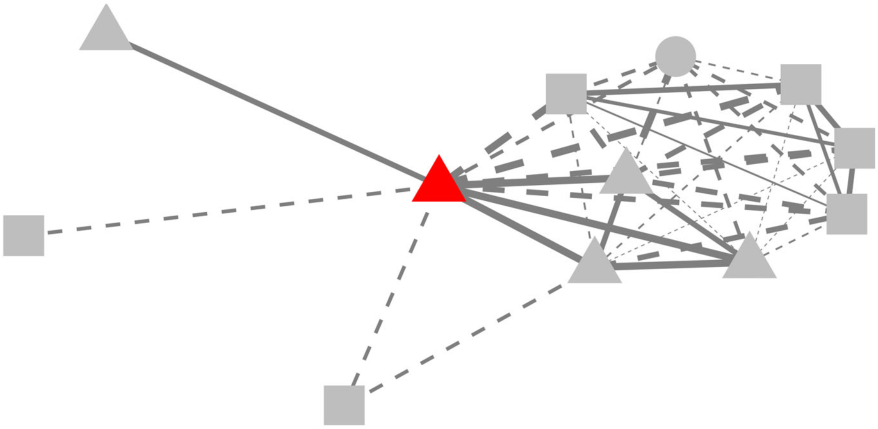

FIGURE 3 Learning space for Case II. Node shapes: triangles (public sector), square (private sector), circle (civic sector). Node color:red (Ego), gray (Alter). Link type: dash (divergent interlevel relationship), solid (convergent interlevel relationship). Link strength: increases with strength of the link connecting any two nodes

TABLE 2 BW analysis, relational strength (Indicator 3)

Cumulated strength				
Interlevel relations		**Intersector relations**		**Overall**
Yes	No	Yes	No	
536	414	792	158	950

Abbreviation: BW, Baden-Württemberg.

polycentric administrative scales, though, not to the same degree. Generally, intersectoral connections are more prevalent and more active than others. With less than two-third of the polycentric triads realized, we assume that there is room for more polycentric exchange without adding actors to the network. While the network is dense, with frequent interactions, weighted centrality and triad census still show a certain structure of information exchange. The measurements support the expectations that all indicators of collaborative governance are present in the broker's immediate network.

5 | DISCUSSION

Collaborative flood risk management arrangements, comprising diverse interests and decision centers, as well as frequent and well-integrated interactions between stakeholders, represent a crucial element in flood risk governance (Eisenack et al., 2014; Pahl-Wostl, 2009). The facilitation of these complex networks is resource intensive (Matczak et al., 2018). In a fairly unregulated policy domain, individuals in brokerage positions are expected to drive the exchange of information and thus the development of a collaborative arrangement (Ansell & Gash, 2008). In our study, we identified four properties of broker learning spaces that we proposed could serve as indicators of the presence of 6 of the 10 indicators of collaborative governance. The proposed indicators are: the diverse interests represented in the brokers' network, the polycentricity of their network, the proportion of strong relationships in their network and the density of their network. To verify our four indicators, we conducted egocentric surveys to capture and describe brokers' learning spaces.

The above analysis focuses on broker networks in flood risk management arrangements that are currently engaged in efforts to establish collaborations in an unregulated policy domain. In the case of NRW, we are looking at a fairly new regional collaboration (introduced above as the Water in the City of Tomorrow initiative) that intends to adapt the green and blue infrastructures for densely populated areas in the Emscher-Lippe region to accommodate an increasing demand for drainage. In the case of BW, the arrangement was well established but entered a new collaboration to accommodate the new risks from sediments and large woods. From each study area, we selected the municipal brokers as a case study (in each case one person). In each instance, we observed properties in the broker's learning space that are indicative of what we would expect from a collaboration that can successfully tackle the common challenges posed by heavy rains.

5.1 | Diversity decision centers and interests

In BW, the broker's network integrates multiple interests and decision centers, which in this study, we define along the dimensions of sector (public, private, and civic) and administrative levels (municipal, state). However, the diversity is predominantly based in public and private actors, with only 1 civic actor out of 11 alters. This diversity is not reflected in the case of NRW. The analysis presented in this article shows that, compared to the case in BW, the broker in NRW maintains a network that is neither diverse (in terms of the represented interests) nor polycentric, which is indicative of the absence of a collaborative governance arrangement.

5.2 | Strength and density of information flow

We find that in both cases, the exchange of information is not centrally controlled but flows via multiple channels between the stakeholders in the observed collaborations. Hence, it is not one person but a collective that manages the flow of information. In BW we also observe a high proportion of intergroup relationships that go beyond a mere consultation. To the contrary, in BW we observe an intense exchange of information between administrative levels and sectors. This is not the case in NRW, due to the lack of diversity in the broker's network.

5.3 | Explaining variations

The observed variations (summarized in Table 3) imply that the broker's learning space in BW mirrors a collaborative governance arrangement, encouraging more interactions across levels and sectors than the one in NRW. Both learning spaces reflect the governance arrangements in the federal states in terms of collaboration, since the one in BW was already drawing on a history of collaborative approaches, whereas the initiative, "Water in the City of Tomorrow," in NRW was planned exclusively between municipalities and the Emschergenossenschaft. The broker's learning space shows that there was no intent to further involve additional actors from other sectors or governance levels. The emergence of a broker's collaborative learning space does not seem to constitute an automatic mechanism, created in order to enhance the provided information or knowledge in a network. Also in the case of Baden-Würtemberg, the broker's learning space showed little diversity in regard to civic actors, which are, in general, not very involved in flood risk management throughout the German federal states (Kochskämper & Newig, 2020; Newig et al., 2014). It seems that without further establishment of rules, norms or guidance, collaborative governance arrangements do not necessarily tend to materialize in fairly unregulated policy domains via the individual role of brokers. Additionally, the different governance arrangements addressing similar risks point to a lack of governance learning between different German federal states, a characteristic which was already found to be present in the employment of participatory processes under the EU Floods Directive (Newig et al., 2016).

TABLE 3 Indicators of collaborative governance present by case (× = absent, ✓ = present)

Indicative of collaborative governance	NRW case	BW case
Indicator 1: Polycentricity	×	✓
Indicator 2: Diversity	×	✓
Indicator 3: Strong relationships	✓	✓
Indicator 4: Learning spaces that are dense with low levels of centralization	✓	✓

Abbreviations: BW, Baden-Württemberg; NRW, North Rhine–Westphalia.

6 | LESSONS FOR GOVERNANCE RESEARCH

The focus of the study presented here is on the individual networks, what we term learning spaces, of brokers in German flood risk management. By applying the method of egocentric network analysis, we traced whether the brokers' learning spaces, in two cases, were indicative of collaborative governance arrangements, and whether brokers were driving collaborative governance arrangements. Our findings show that it is possible to grasp the nature of a governance arrangement by zooming in on the properties of a broker's learning space. Furthermore, our findings show that brokers do not automatically expand their learning space in ways that drive more collaboration. The existing information flows in flood risk management arrangements. The paper presents case-specific findings on information flows and learning spaces.

6.1 | Strengths

The novelty of the method we applied is the tracing and verification of actual information flows between individual actors, from a broker's perspective. From these clearly drawn patterns, we can draw conclusions about information exchange at the level of individual relationships, and about the centralization of the learning spaces that emerge from them. This systematic analysis allows us to identify and evaluate the properties of a broker's learning space that are indicative of a collaborative flood risk management arrangement. Upon this basis, it is possible to recommend a next step which would show how to potentially optimize a broker's learning space to ensure the growth of a collaborative governance arrangement.

Our approach complements existing methodologies in that we ask study participants to identify and quantify (e.g., frequency of contact) their relevant contacts and the observed interactions between these contacts. In other words, we add to our questionnaire name generating and name interpreting questions (see for a detailed introduction Witting, Brandenstein, & Satoh, 2020). To capture an objective description of this particular network, we also survey the participant's contacts. Being able to map the interactions in a broker's learning space from multiple perspectives has the advantage of depicting the actual interdependencies of the interactions present in this network. Thereby, the method allows the identification of possible gaps in the information flow, assesses the potential impact on the network if an actor were to retire, and demonstrates whether the individual network of a broker mirrors the formal structure of a governance arrangement. Our approach generates not only reliable, but also comparable data (Witting, Brandenstein, & Satoh, 2020).

6.2 | Weaknesses

While this approach clearly has many merits, it needs to be optimized. First, as with all social network analysis, missing data introduces errors and prevents conclusions from being drawn with regard to our indicators. Data gaps result from the respondents' lack of willingness to fully answer the survey questions. We find that brokers that are confident that the survey findings will reflect what they consider to be a success story will be more thorough in their response. Hence, our current approach is more likely to yield extensive information about learning spaces that are embedded in mature collaborations. Having said that, research presented in Ulibarri et al. (2020) caution that effective leadership can decrease over time.

Second, the measurements of diversity and polycentricity must be grounded in an empirical analysis that identifies case-specific interests and the level of polycentricity needed in a particular setting. Our pilot relied on normative proxies, such as the differentiation between the state and municipal level of decision-making, which may not accurately reflect the situation on the ground. Considering the irreducible nature of socio-ecological systems, it seems fair to assume that interests and the number of relevant decision centers may vary from case to case. Hence, standardized proxies to measure interests and polycentricity are more likely to return errors. Finally, while the method produces generalizable data in theory, for the insights from this study to be generalizable we would have needed to compare a much larger number of cases. This comparison of two cases serves as a pilot to inform such a study.

6.3 | Where to go from here

More specifically, we can compare variations in the size and patterns of a broker's learning spaces to the varying nature of the risk when marching a collaboration across time or comparing it across space.

Through these joined inquiries we can identify and compare variations in the size and patterns of brokers' learning spaces across time and space. Through these inquiries, we can gradually build an evidence base of best practices that can serve as a foundation to further develop and test theories concerning the effect of brokerage on collaboration and learning in flood risk management.

ENDNOTES

[1] While degree centralization clearly withstands a conditional uniform graph (CUG) test, the betweenness score is typical for randomly generated graphs of the same size or edge count (see Footnote 3). A CUG test renders graphs (using a Monte Carlo simulation), keeping either the number of edges, or the size constant, and applies the statistic of interest (Butts, 2008). Replicated numerous times, the resulting distribution indicates whether the condition alone is a likely cause of the measurement result. In a CUG test of betweenness, of 10,000 replications, 99.9% scored lower than our observed graph, for degree 97.7% of the simulated networks. Therefore, we can be confident that the effect is not a mere artifact springing from size or edge count.

[2] Link strength for four edges is missing in our data (10%). For our calculations, we decided to replace missing values with the median strength value of either diverse, or nondiverse, respectively, assuming that this is a more realistic approach than, for example, setting them to 0.

[3] The CUG test indicates that it is highly unlikely that these scores are mere size effects.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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APPENDIX

To operationalize the first property of a broker's learning space (Indicator 1), we assumed that an information exchange between state-level and municipal actors can serve as a proxy for the representation of different centers of decision-making (polycentricity). As a measure, we virtually broke-down a given network into all possible combinations of three actors (triad), and counted which of those triads connected actors across these two levels (see Figure 4 for an example). We compared this with the most polycentric network theoretically possible, a network G with n nodes and α diverse groups of interest (two in this case), where all possible polycentric triads were realized. The maximum number D of these triads can be calculated by Formula (A1). Other studies may also wish to capture decision centers for the different problem domains at each level, such as, for example, urban planning, or transport planning. Our study focused on the policy design stage, during which municipal experiences are communicated to state actors that design flood risk policies and plans.

$$Div_{max(G)} = \begin{cases} \dfrac{n!}{3!(n-3)!} - \left(\alpha \dfrac{\left(\frac{n}{\alpha}\right)!}{3!\left(\frac{n}{\alpha}-3\right)!}\right) & ,\text{if } n \bmod \alpha = 0 \\ \dfrac{n!}{3!(n-3)!} - \left((\alpha - n \bmod \alpha)\dfrac{\left\lfloor\frac{n}{\alpha}\right\rfloor!}{3!\left(\left\lfloor\frac{n}{\alpha}\right\rfloor-3\right)!}\right) - \left(n \bmod \alpha \dfrac{\left\lceil\frac{n}{\alpha}\right\rceil!}{3!\left(\left\lceil\frac{n}{\alpha}\right\rceil-3\right)!}\right) & ,\text{otherwise} \end{cases} \tag{A1}$$

To operationalize the second property of a broker's learning space (Indicator 2), we utilized the same proxy as above for the representation of different sectors, and therefore different interests, in a given network (public, private, civil society). A diverse triad in this regard connects actors from at least two of these three groups ($\alpha = 3$). See for details Formula (A2) in the Appendix.

To obtain a measurement of the third property of a broker's learning space (Indicator 3), we assumed that frequent interaction is indicative of strong relationships in individual learning spaces. We therefore measured the strength of a relationship by surveying interaction frequency between an Ego and its Alters and, from the perspective of Ego, between the different Alters. The focus here was on relationships that link the different sectors (cross-sector relationships) and levels (interlevel

$$D_{max(G)} = \begin{cases} \dfrac{n!}{3!(n-3)!} - \left(\alpha \dfrac{\left(\frac{n}{\alpha}\right)!}{3!\left(\frac{n}{\alpha}-3\right)!}\right) & ,\text{if } n \bmod \alpha = 0, \\ \dfrac{n!}{3!(n-3)!} - \left((\alpha - n \bmod \alpha)\dfrac{\left\lfloor\frac{n}{\alpha}\right\rfloor!}{3!\left(\left\lfloor\frac{n}{\alpha}\right\rfloor-3\right)!}\right) - \left(n \bmod \alpha \dfrac{\left\lceil\frac{n}{\alpha}\right\rceil!}{3!\left(\left\lceil\frac{n}{\alpha}\right\rceil-3\right)!}\right) & ,\text{otherwise.} \end{cases} \tag{A2}$$

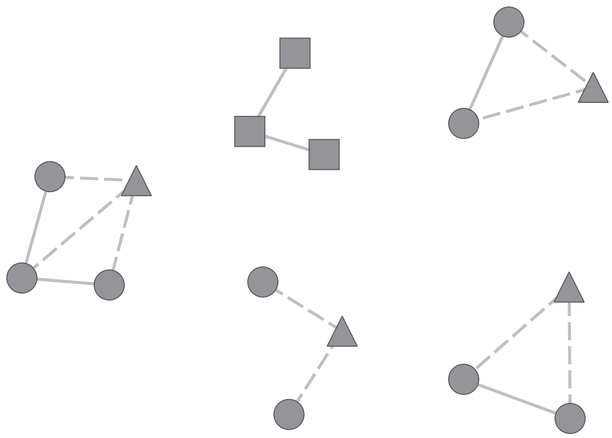

FIGURE 4 Example graph (left) connecting two distinct groups of nodes (filled either gray or white). It can be broken down into four triads (right), of which three are diverse as they connect nodes of different groups

relationships), as these are indicative of an individual's exposure to different perspectives, and can lead to collective learning and action (see, e.g., Pahl-Wostl, 2009). Where we lacked information about relational strength, we assumed a base value of 1–3 instances of contact, subsequent to the flood event, during which information was exchanged, as this was the mean value of the relations, we were able to survey. We also analyzed the cumulative value of intersector and interlevel interactions, accounting for relational strength between sectors.

The fourth and final property of a broker's learning space (Indicator 4) is strongly related to the formal concept of *network centralization* (Freeman, 1979). In general, centralization levels are lowest in networks where every node is directly connected to every other node, and highest in star-shaped networks, with a dominant node in the center. More centralized networks are seen to reflect a more hierarchical setting. In the seminal formulation by Freeman (1979), centralization measures solely consider the number of edges connecting nodes.

We focused on two variants, *betweenness centralization* and *degree centralization*. Betweenness centralization is high when the shortest paths between nodes in a given network are often leading past the same nodes. Those nodes are then central to the control of information flow. Degree centralization, on the other hand, depends on how many edges end in one node (ibid.). With fewer nodes being densely connected, and more nodes being only sparsely linked, degree centralization grows, being highest in the already mentioned star-shaped network.

The above measures have been computed with base R (Version 3.6.1), the numbers (0.7–1), tnet (3.0.14), and statnet library (2019.6). Plots have been generated using GGally (1.4.0) and its ggnet2 function.