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The Added Value of Understanding Informal Social Networks in an Adaptive Capacity Assessment: Explorations of an Urban Water Management System in Indonesia

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Abstract Social networks play an important role in environmental governance regimes, and they are a key to the adaptive capacity of systems that deal with complex, contextual and multi-faceted issues. Urban water systems are typical examples of complex systems facing many pressures, such as increased population, water quality deterioration, and climate change. This paper explores social networks of the key stakeholders engaged in urban water management, in Makassar City, Indonesia, in the context of exploring ways to improve management of an increasingly complex urban water system. Three social networks were explored; those constituted by formal and informal interactions and networks perceived by stakeholders to be "ideal". Formal networks were identified through an examination of the legislative instruments and government agencies' documents relating to water provision in Makassar, while the informal and "ideal" networks were investigated in collaboration with the stakeholders. The research found that the informal social network was more extensive than were the formally required networks, and the investigation of informal networks created

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a potentially more robust and adaptive water management system than would have occurred through inclusion of formal institutional arrangements. We suggest that in examination of the adaptive capacity of an urban water system, one also considers the informal arrangements and linkages, as this additional information about the system is necessary to enhance our understanding of potential adaptation of water management and improved urban water systems.

Keywords Adaptive capacity · Complex adaptive systems · Institutional arrangements · Integrated urban water management (IUWM) · Makassar · Perceptions of water system

1 Introduction

Fresh water availability is one of the most pressing global issues with many countries facing challenges posed by increasing demand for limited water supplies in the face of periodic droughts, and the depletion and contamination of surface and groundwater. This has implications for policy and planning processes required to secure adequate supplies into the future. Urban water systems are particularly reliant on the interaction between humans and their urban socio-technical environments (Alexander et al. 2010). The development of water management policies, including urban water management, thus requires evidence that deals with complex, contextual and multi-faceted issues and underlying drivers, as well as support by governance arrangements capable of processing such issues (Wiek and Larson 2012). Pahl-Wostl (2009) has suggested that successful governance regimes of natural resources have four important characteristics: (i) the existence of and relationships between formal and non-formal institutions ('institutions' comprising of rules, arrangements and organisations); (ii) roles for and integration between state and non-state organisations; (iii) multi-level administrative interactions and differentiation between the governance modes of bureaucracies, hierarchies, markets; and (iv) networks. In this paper we explore in detail one of those characteristics, the social networks of the key water stakeholders, in the context of the identification of potential for improving the management of city of Makassar's increasingly complex urban water system.

One approach to manage complexities and uncertainties within any complex system is termed adaptive governance, commonly used in the study of social-ecological systems (Folke et al. 2005), and is also applicable to socio-technical systems such as urban water systems (Moglia et al. 2011). Adaptive governance can be described as a systematic process for continually improving policies and activities by learning from the outcomes of actions and activities. Dietz et al. (2003) define adaptive governance as a process by which institutional arrangements and ecological knowledge are continuously tested and revised through dynamic, self-organised and learning-by-doing processes. Olsson et al. (2006) added that key factors in the adaptive governance process tend to be: (i) building knowledge, (ii) networking, and (iii) leadership. Folke et al. (2005) point out that adaptive governance systems often self-organise as social networks, with groups drawing upon various knowledge systems and experiences in order to develop a common understanding of a system and what policies affect it.

Urban water systems are typical examples of complex adaptive systems facing pressure from a number of drivers, such as increased population, water affluence, agricultural and environmental water needs, climate change etc., and thus require adaptive governance with capacity to facilitate changes (Moglia et al. 2010, 2011). Urban water systems are normally managed via a bundle of agencies, each typically has only limited and specific

responsibilities (Larson and Stone-Jovicich 2011). Thus, there is a risk that certain components of the water system start functioning independently of the other components—which may be managed by a different agency. This will potentially create a 'silo' effect. This reduction of what is inherently a complex system, to the level of a single part or a particular goal, has the potential to significantly undermine outcomes of management actions (Moglia et al. 2010). Decisions on water management taken independently by one agency can lead to rippling effects on linked agencies within the system, diminishing or aggravating their operating performance (Smajgl and Larson 2007). To improve performance of the system, Schiffer and Hauck (2010) have argued that it is essential to understand the processes, linkages and dynamics between agencies, and that the success or failure of natural resource policies, projects, or management is to large extent determined by functional operation of these complex processes and linkages.

The research presented here was undertaken as a component of a project employing a multi-stakeholder approach to explore ways to improve management of increasingly complex urban water system in the city of Makassar, Indonesia (Fig. 1), where future management planning also needs to account for climate change (Kirono et al 2013). One of the shortcomings of existing tools and methods for assessment is that they tend to focus on formal administrative structures, those being explicitly stated in policy documents and laws, despite the acknowledgment that these may have little to do with the everyday reality of natural resource management (Stein et al 2011). However, as Stein et al (2011) point out, there is an increasing demand to find ways to also capture and analyse what has been referred to as informal institutions, and established and reproduced informal networks of information sharing and collaboration between the multitude of actors that make up different governance arrangements. In this publication we present an exploration of several water sector networks using the social network analysis (SNA) method.

The SNA method is increasingly used to describe complex patterns of formal and informal interactions between different actors (individuals or organisations) engaged in natural resources management or NRM (for arguments for the value of SNA for NRM studies see work of Bodin et al. 2006; or for an excellent presentation of social network concepts and summary of empirical studies refer to Bodin and Crona 2009). Instead of analysing the characteristics or the formal hierarchical structure of an organisation, the SNA focuses on the networks fostered and maintained by that organisation (Schiffer and Hauck 2010). Examples of application of SNA in urban setting are very rare (for example, see work of Ernstson et al. 2010 on protection of urban ecosystems in Stockholm). This paper presents one of the first examples of use of SNA methodology for the assessment of management structures of an urban water system.

In this paper we employed social network analysis method to identify, compare and contrast three networks: (i) formal networks, that is, networking as required by current legal, management and other formal institutional arrangements; (ii) informal networks, or existing linkages between various actors in the network that are based on informal arrangements or personal contacts; and (iii) ideal networks, or the structure and linkages of a social network that would, stakeholders believe, enable optimal functioning of the urban water system. We build our research on the proposition that networks are an important component of successful environmental governance regimes (Folke et al. 2005; Olsson et al. 2006; Pahl-Wostl 2009), and argue that a well-connected bundle of organisations is required for robust yet adaptable urban water management system, where connections allow for adaptive learnings and practices to diffuse through the bundle. Thus, we test the three types of networks between organisations engaged in the management of urban water system of city of

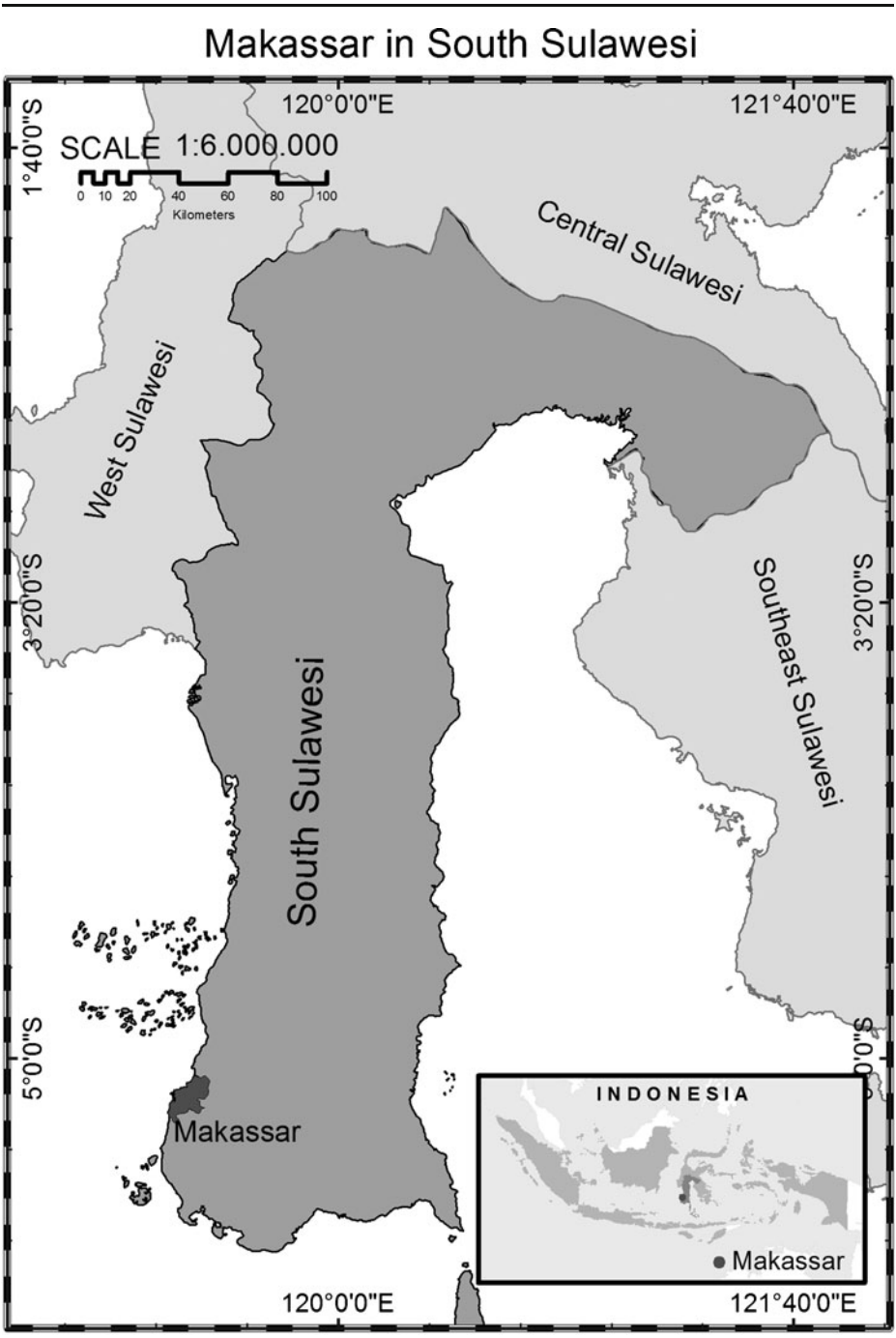

Fig. 1 Location of Makassar City, South Sulawesi Province of Indonesia

Makassar to assess their connectedness and infer on their capacity for successful management and adaptation in the future.

2 Urban Water Management in Makassar City, Indonesia

2.1 Water Governance in Indonesia

Water supply in Indonesia is regulated through the Law number 7/2004 regarding Water Resources. The Law regulates and clarifies the roles of the national, provincial and local governments to enable integrated and sustainable water management (GoI 2004). A National Policy and Strategy of Management of Wastewater Systems was also developed by the Ministry of Public Works and the Sanitation Road Map was issued jointly by the National Development Planning Agency (BAPPENAS) and Ministry of Public Works, Health and Home Affairs (AIP 2010). While nationally, there are several agencies involved in the management of water, the BAPPENAS retains the central role of ensuring national coordination. Public water and sanitation services are mainly shared between the Ministry of the Public Works, Ministry of Forestry, and the Ministry of Health.

Urban water management in Indonesia has experienced transition and transformation in recent years. Subandi (2005) categorised three key stages of this transformation: (i) during the 1970s–1990s period public water provision was centrally managed by the national government, (ii) the late 1980s to early 2000s saw a shift in management to the provincial governments and (iii) late 1990s to current period in which water provision has been managed by the local (municipal) governments. Changes in urban water management in Indonesia are in line with a wider international movement for decentralisation and devolution of a range of national responsibilities, including environmental and resources management (Agrawal and Gibson 1999; Friedmann 1998; Larson and Brake 2011; Ribot 2002; Wondolleck and Yaffee 2000). As a result, the provision of urban water services is formally managed by the PDAMs (Local Government-owned Water Utility Companies), while other aspects of urban water management, such as wastewater and sewerage services, are shared among the local government entities. This devolving of responsibility and decentralisation of power to the local governments means that resource-constrained local governments are responsible for improving all aspects of water, including improving access and service quality. The current Government of Indonesia policy for the national urban water sector is to increase the level of investment by local governments, improve the credit worthiness of the PDAMs and assist PDAMs to access commercial lending for the expansion of services (AIP 2010).

2.2 Makassar City Urban Water System

Makassar is the capital city of South Sulawesi Province and is known as the gateway to eastern Indonesia. It is the most urbanised city in the eastern part of Indonesia, with the estimated population of over 1.2 million in 2006 and projected population growth of around 2.7 % (BPS Makassar 2007; CV Globalindo Konsultama 2006). Many infrastructure, urban and industrial developments have taken place and/or are planned, generating increased pressure to supply water for industrial and domestic purposes. Two rivers, one with the major water storage dam, provide water for the city, which is treated and distributed by the municipal water authority (PDAM) (Barkey et al 2011). In addition, groundwater is widely exploited as a water source. Households often have access to shallow water wells, and deep bores are used by industry and commerce to supplement PDAM water supply (Barkey et al. 2011).

Makassar is already struggling to meet the demand for clean water supply. Up to 2009, the Makassar PDAM supply network covered 62 % of the city's total population (Barkey

et al 2011). Poor communities are serviced by communal hydrants, well water or purchased water from vendors. Wastewater services in Indonesia are historically less developed than water services. In Makassar city, the majority of households are connected to septic tanks that diffuse waste water into the soil. Greywater (from kitchen, showers etc.) flows into open stormwater drains and channels that discharge either into the rivers or directly to the sea. In the peri-urban areas and where rapid urbanisation is occurring, e.g., slum areas, the processing of wastewater is unlikely to occur. This situation negatively impacts upon water quality and poses serious health risks during flood events (Barkey et al 2011).

3 Methods

3.1 Key Stakeholders Identification

In general, stakeholder analysis is an approach or tool used to obtain knowledge and information about stakeholders, their interests, importance, influence, resources and so on (Stanghellini 2010). To understand the stakeholders involved in managing the water supply system in the city of Makassar, a 3-day workshop was held in October 2010 at Hasanuddin University (UNHAS). Representatives for the workshop were selected using a snowballing method until no new organisations were mentioned. The final set of 32 representatives included those from government agencies at the city, regional, provincial and national levels; non-government organisations; and science and research organisations. The main objective of the workshop was to explore perceptions of institutional arrangements for water management in the city and the rivers used in the urban water supply (Larson et al. 2010a). The workshop also included discussion on key stakeholders, defined as those who "could significantly influence, or were important for the successful functioning" of the water system (ODA 1995). The selection of "key stakeholders" was validated against the results of the formal network analysis that highlighted the actual legislative and regulatory roles held by agencies. The final list of key stakeholders agreed upon at the workshop, and used in the SNA, included the following:

- Municipal Water Company – PDAM,
- Sanitary and Landscape Office – DKK,
- Municipal Public Works – DPU,
- Department of Health – DINKES,
- Water Resources Management Agency – PSDA, and
- Department of Environment – BLH.

3.2 Social Network Analysis

The social network analysis (SNA) method was used to analyse networking among key stakeholders of Makasssar's water system. We employed the SNA to identify, compare and contrast three networks: (i) formal networks, that is, networking as required by current legal, management and other formal institutional arrangements; (ii) informal networks, that is linkages between various actors based on informal arrangements or personal contacts; and (iii) ideal networks, or the structure and linkages of a social

network that would, actors believe, enable optimal functioning of the urban water system (Fig. 2).

The formal social networks (SNs) comprise networking that is required under legal, management and other formal institutional arrangements. An assessment of the formal networks was developed based on formal documents of each of the stakeholder organisations. Formal networking was assessed by exploring the shared roles and responsibilities in relation to the relevant laws and legislation, as well as organisations' shared jurisdictions in relation to aspects of water, such as potable water provision, sanitation, pollution prevention, watershed management, water-borne diseases control, etc.

The informal or shadow SNs on the other hand are linkages between actors, that is, consultations or collaborations that are not a legal requirement. To assess the extent of these networks in the current system, members of upper management from each key stakeholder agency were interviewed and asked the following question: *"Which organisations (government and other) has your organisation collaborated with, within the last 3 years, on the issues of water?"* (Fig. 2). As this question was about collaboration between agencies, and not only personal collaboration, people holding positions of section heads or higher were deemed as having sufficient understanding of organisational functions, and thus were suitable to be interviewed.

Information on the "ideal" SNs, the structure and linkages of a social network that would, in the view of respondents, enable optimal functioning of the urban water system, was generated by asking the following of upper management interviewees: *"Which organisations (government or other) you think you should be collaborating with in order to achieve the best outcomes for management of urban water in Makassar city?"*. For both informal and ideal networks, respondents were asked to include all types of collaborations, from financing and consulting, to international collaborations and collaborations with industry and science providers (Fig. 2).

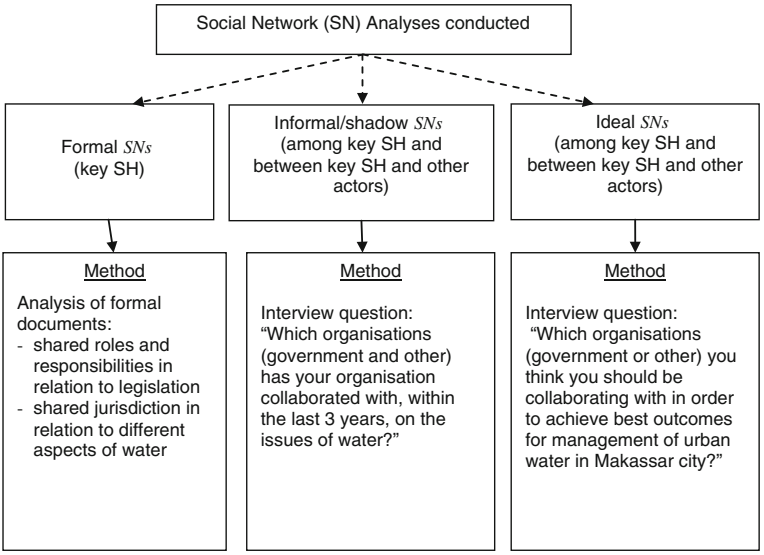

Fig. 2 Three stakeholder (SH) network analyses conducted

3.2.1 Structural Characteristics of the Network

Network thinking has contributed a number of important insights about social power (Hanneman and Riddle 2005a). In particular, it emphasises that power is inherently relational: an individual or agency have power as a consequence of their patterns of relations with the others. Social power is both a systemic (i.e. macro, one that describes the entire population) and relational (i.e. micro, it describes relations between one actor with others) property. In this paper we were interested in exploring the urban water management networks; rather than any one stakeholder in particular. Thus, a systemic macro approach, that is an approach that focuses on the pattern of connections in the network as a whole, was used. Further, structural characteristics of the network were assessed using a concept of degree centrality. The degree centrality is, simply put, the number of ties an actor possesses (or in this case, a number of linkages an agency has) with the others in the network.

In order to explore network connections that were identified, the data were analysed using a Ucinet computer program (Borgatti et al. 2002), a formal method for analysis of social network data. For the formal networks analysis, a degree of centrality was also calculated. Based on the numbers of ties agency and its neighbors have, calculations of the degree of centrality allow for an assessment of variance in connectedness of different actors in the network—and hence, an assessment of the potential power inequalities within the network. This is an important measure as social network theory suggests that organisations which have more ties to others, that is, a more central position, might be in an advantaged position compared to others. Network centralisation was calculated using the Freeman's graph centralization method and is expressed as a percentage of a perfect theoretical maximum (i.e. higher percentages indicate greater inequality, Hanneman and Riddle 2005a). The shares of the formal network held by each organisation were then also calculated. The Freeman's graph centralization method (Freeman 1979) was used as it describes the population as a whole, at the macro level. An alternative—and arguably superior—approach and measure of centralisation was developed by Bonacich (1987). He argues that power or 'status' in social networks should be determined, in addition to positive relationships captured by the Freeman's method, also by presence of the negative relationships (i.e. while being liked by popular individuals confers status, being disliked by these same individuals is particularly harmful). As a part of our analysis included formal networks that are required under legal, management and other formal institutional arrangements, this method was not deemed appropriate to be used in this case. The Net-draw visualisation tool based on the graph theory (Hanneman and Riddle 2005b) was used to graphically analyse and present the data. A graph theoretical spring embedding layout method (Borgatti et al. 2002), a method similar to multidimensional scaling approaches as the algorithms use iterative fitting to arrive at graphs that locate smallest path lengths adjacent to each other, was used.

4 Results

4.1 Formal Networks of Key Stakeholders

The formal linkages among the six key stakeholders identified during the stakeholder consultation were investigated. Initially, investigations were focused on the formal legislative requirements for sharing responsibilities between agencies (Fig. 3a). This indicates strong linkages between the DPU (Municipal Public Works), DKK (Municipal Sanitary and Landscape Office), BLH (Department of Environment) and PSDA (Water Resources

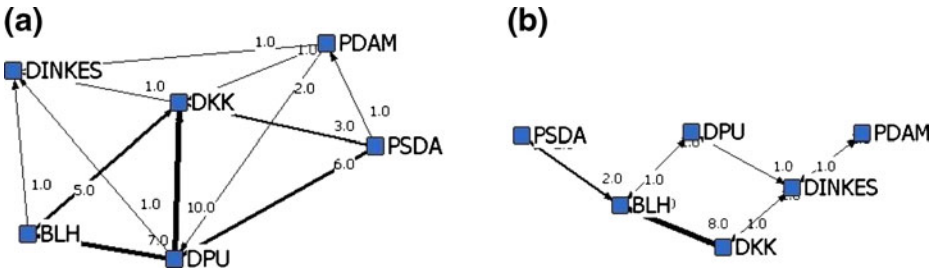

Fig. 3 Net-maps of (**a**) formal legislative requirements for collaboration between agencies and (**b**) aspects of water (quality, sanitation etc.) under shared jurisdiction, key stakeholders in Makassar urban water system; *numbers on lines* indicate numbers of shared links (responsibilities)—for example, in (**a**), DPU and BLH have 7 shared responsibilities

Management Agency). As all of these agencies have complex and varied portfolios, the results could be considered indicative. In contrast, the DINKES (Department of Health) and PDAM (Municipal Water Company) had limited linkages to other actors in the urban water system, indicating that their operational portfolios were restricted to more discrete jurisdictions, that is, public health and clean water provision, respectively.

Formal linkages among the six key stakeholders were also probed concerning the levels of shared responsibility for the different aspects of water management, such as pollution prevention, provision of clean water, water borne diseases, sanitation, maintenance of infrastructure, watershed protection etc. (Fig. 3b). The BLH (Department of Environment) and DKK (Municipal Sanitary and Landscape Office) emerged as having more shared responsibilities, followed by the DPU and DINKES, with the remaining two agencies possessing lower levels of shared water management responsibilities.

This network based on formal requirements also had a rather high degree of centralization, that is, a high degree of inequality among agents. The largest network share or most "power" in the network was held by the DPU (0.326), followed by DKK (0.244). The BLH and PSDA had smaller shares of the network, i.e. 0.151 and 0.128, respectively, while the DINKES (Department of Health) and PDAM (Municipal Water Company) had limited linkages to other actors in the system, resulting in a network share of only 0.047 for each.

4.2 Informal and Ideal Networks: Beyond Key Stakeholders

Directors or equivalent upper management position holders in the six key stakeholder organisations were asked about their organisations' informal linkages during the last 3 years, beyond those expected based on legislative and management documents. Figure 4 indicates that the actual network of past collaborations is much more complex than what would be expected based on estimations from the formal requirements for collaboration. Nineteen additional collaborators were identified, many of them having collaborated with more than one key organisation (Table 1). A total of 67 collaborations (ties) were reported by key stakeholders during the last 3 years. A number of non-government organisations (identified in Table 1 and presented as light circles in Fig. 4) formed part of this informal network. In addition, Non-Governmental Organisations (NGOs) were found to have a high network centrality, with connections to most of the six key stakeholders (which are presented as squares in Fig. 4). Particularly well connected were Hasanuddin University (UNHAS) and the international NGOs and aid agencies (International NGOs/AA, Fig. 4).

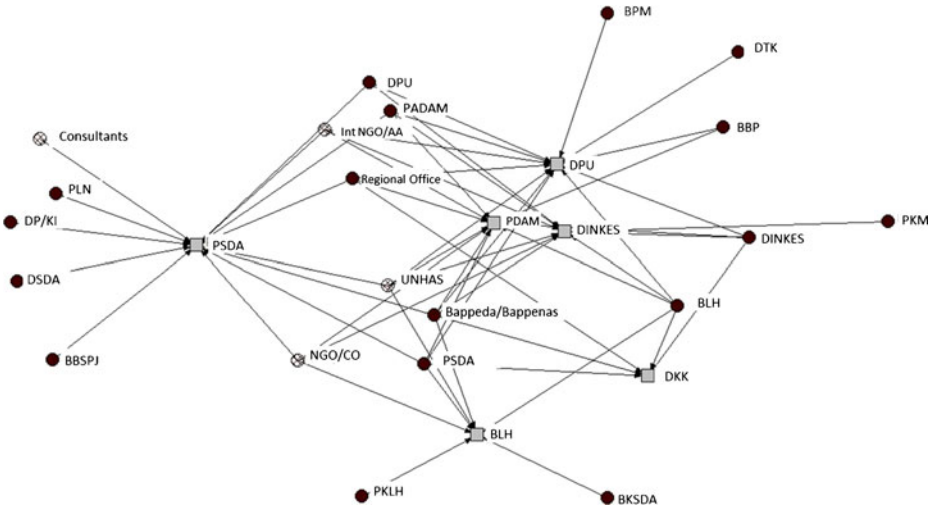

Fig. 4 Net-map of organisations that have collaborated on some aspect of water in the last 3 years, (*square*= key stakeholder; *circle*=collaborator: if *dark*=government; if *light*=not government)

Table 1 Network participants identified by representatives of six key agencies

Network participants	Acronym
Non-government:	
Local non-government and community organisations	NGO/CO
International NGOs and Aid agencies	Int NGO/AA
Hassanudin University	UNHAS
Contractors and technical consultants	Consultants
Agency for the Assessment and Application of Technology	BBP
Government:	
Department of Agriculture Irrigation office	DP/KI
Planning Department South Sulawesi Province	Regional Office
Planning Department	Bappeda/Bappenas
Ministry of Environment Regional Centre	KLH
Dept. of Forestry Natural Resources Conservation Unit/Watershed Area Management Office	BKSDA
Watershed Management Office for Jeneberang River	BBSPJ
Land use and urban planning department	DTK
State Electricity Department	PLN
Water Resources Management Agency	PSDA
Local community health centre	PKM
Bureau of Meteorology, Climatology and Geophysics	BMKG
National Land Agency	BPN
Regional House of Representatives	Politicians
Department of Transportation	

Key stakeholder representatives were also asked to reflect on a network that would, in their view, be ideal for supporting optimal functioning of the Makassar urban water system into the future (Fig. 5). A total of 78 linkages were generated via this question. The Department of Transportation; the Bureau of Meteorology, Climatology and Geophysics (BMKG); and the National Land Agency (BPN), were added to the network, as well as political representatives (Regional House of Representatives, Table 1). In this scenario, the number of shared connections between the existing urban water network participants did not increase compared to the current state of collaborations. Hasanuddin University (UNHAS) and the international NGOs and aid agencies (International NGOs/AA) maintained their important positions in the "ideal" network, while the perceived importance of local NGOs increased in the "ideal" network.

5 Discussion

Social networks have been identified as an important component of successful environmental governance regimes (Folke et al. 2005; Olsson et al. 2006; Pahl-Wostl 2009; Stein et al 2011). Furthermore, cooperation between organisations in any complex system has been identified in the literature as one of the key aspects of adaptive capacity (Pelling and High 2005a; Preston and Stafford-Smith 2009). In this paper we have argued that a well-connected bundle of organisations is required for a robust and adaptable urban water management system, where connections allow for adaptive learnings and practices to diffuse through the bundle. We tested the connectives of the urban water system of city of Makassar, Indonesia, and used this information to infer the systems' potential to adapt and learn in the future.

Social networks among stakeholders can be assessed in several ways. Assessments of formal institutional arrangements are common, as they rely on secondary data and thus avoid potentially time-consuming and costly primary data collection. However, the formal

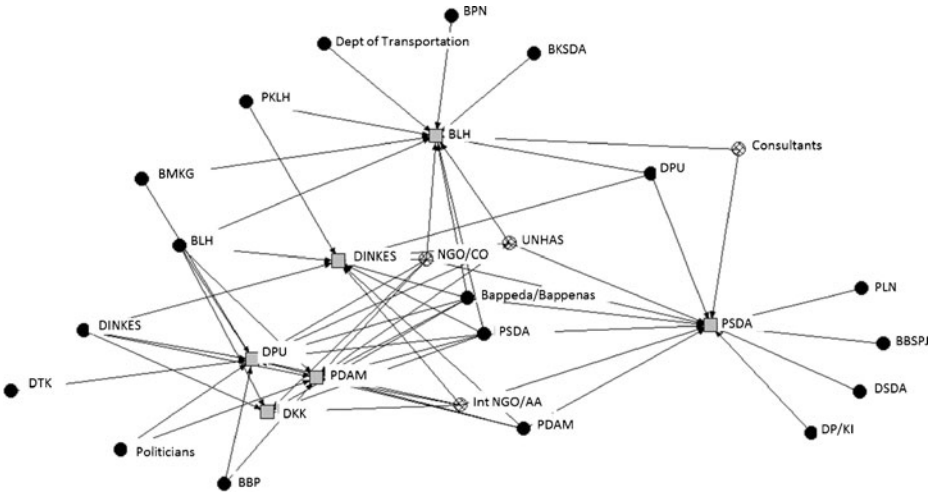

Fig. 5 Net-map of an "ideal network" (i.e. organisations that should collaborate together) for the optimal operation of the Makassar urban water system as perceived by stakeholders; (*square*=key stakeholder; *circle*=collaborator: if *dark*=government; if *light*=non-government)

institutional arrangement might not well represent the actual collaborations between the organisations (Stein et al 2011). As a result of our research findings, we argue that analyses of informal networks (constituted by collaborations) give a better representation of the actual levels of cooperation than the examination of statutory requirements alone. Our assessment of social networks among the stakeholders in urban water management in Makassar shows that informal networks are much more extensive than formal networks, and informal networks are also closer to the "ideal" cooperation perceived by stakeholders.

Assessment of the formal linkages among the six key stakeholders found high levels of network centrality, with the DPU (Municipal Public Works Department) holding the largest network share. This finding indicates that linkages within the formal network are not equally distributed and that the DPU might hold the largest share of "power" in the network. Social network theory suggests that agencies that have more ties to others may be in advantaged positions for several reasons (Bodin and Crona 2009; Hanneman and Riddle 2005a): because they have many ties, such agencies have choices and thus alternative ways to satisfy needs—this autonomy makes them less dependent on any specific other actor or agency, and hence more "powerful"; they are also better situated to access valuable information which can put them at an advantage. An agency with a high number of ties (linkages) is more prominent, and thus might be seen as having high prestige. A high number of ties also allows for exchange of ideas and points of view with many others, potentially making such agencies rather influential. As a result of many ties, such agencies may have access to, and are able to call on more of the resources of the network as a whole, and also have a potential to dominate the other agencies. In addition, agencies that have many ties are often the 'deal makers' in exchanges among others, and are able to benefit from this brokerage. At the same time though, depending on the resourcing to carry out the formal obligations and services, powerful agencies might also suffer from over-burdening of responsibilities.

The analyses of the formal network, constituted by responsibilities of the agencies, found that there was little overlap among the various aspects of water management (e.g. sanitation, water supply, sewerage, etc.). This situation might be seen as desirable in the sense that the water system is managed efficiently in this way. For example, in their study of the urban water management in the Great Barrier Reef region in Australia, Larson and Stone-Jovicich (2011) found that some of the multiple management strategies and plans at various levels (national, state and regional levels) explicitly complemented each other; nonetheless, many others did not align adequately, thus leaving room for management gaps and misinterpretations. Having a system with clear delineation between agency management responsibilities might preclude such management gaps and misinterpretations. On the other hand, however, Smajgl and Larson (2007) warn that agencies with very specific portfolios are in danger of operating in isolation from others in the system, and may be less likely to anticipate and be prepared for future shocks precipitating through the water system.

However, in this study, the level of centrality, and thus relative share of each agency in the network, was found to be much lower in the network defined by collaborations over the past 3 years than in the network defined by legislative responsibilities, and network centrality further decreases in the envisioned "ideal" network. High network centralization has been positively linked to an ability to solve simple problems, while solving more complex problems requires more diverse structures (Leavitt 1951). Research attention has therefore in recent decades shifted to the study of more diverse governing systems, where multiple actors are to various degrees involved in the governing processes (Bodin and Crona 2009). The ideas of diverse structures and diverse governing systems are captured in concepts such as co-management (see, e.g. Carlsson and Berkes 2005), coupled social–ecological systems (see Berkes and Folke 1998), and adaptive co-management (e.g. Armitage et al. 2009). Thus,

governance of any complex system, including urban water systems, through highly centralized networks may not be appropriate (Bodin and Crona 2009). Rather, management of complex systems and processes may function better with less centralised networks that allow for engagement of a variety of actors holding a variety of experiences, knowledge and solutions (Bodin et al 2006).

Decreasing network centrality in "ideal" network indicates agencies' willingness to give up the "power" they have under legislation in order to produce what they perceive as a better water system. This is potentially beneficial form of a water system governance, as the informal spaces and networks allow individuals or sub-groups within the agencies and other organisations to experiment, imitate, communicate, learn and reflect on their actions in ways not encouraged by formal policy and organisational processes (Schiffer and Hauck 2010), and can prevent the formation and entrenchment of "silos" (Smajgl and Larson 2007). One of the dominant hypotheses in the water governance literature suggests that such collaborations create opportunities for learning and innovation, and these opportunities allow for utilisation of local and multiple sources of knowledge as well as provide a room for trial-and-learning process, which can lead to better adaptation strategies over time (Orr et al. 2007; Ostrom 2010). Pelling et al. (2008) also suggest that informal systems might be the biggest contributors to learning and innovation in situations where they are formally recognised but allowed to have a "life of their own".

In addition, all key stakeholders identified and analysed in this research were holders of a "legitimate stake" (Mitchell et al. 1997) in the system. They are government agencies with legislated roles in and responsibilities for the water system. Nonetheless, the network of actual collaborations, as well as the "ideal" network, introduced a number of non-government organisations, some of which with many ties within the network. Such heterogeneous networks were found by Sandström and Carlsson (2008) to be potentially less efficient, but more innovative than the homogenous ones. Bäckstrand (2002) proposed that opportunities for developing knowledge and learning from other stakeholders of different backgrounds create space for outreach and democratise decision making process.

Through the investigation of informal networks we have also furthered our understanding of two other important characteristics of successful governance regimes of natural resources, as proposed by Pahl-Wostl (2009): the existence of and relationships between formal and non-formal institutions; and integration between state and non-state organisations.

Multiple agencies and organisations can play a role in supporting adaptive action, as well as provide pathways through which adaptation is subverted by competing pressures. Thus, investigation of the worldviews and shared understandings held by network participants should form an integral part of the assessment of the adaptive capacity of the water system, as at any given point in time, different stakeholders (government agencies, NGOs and researcher organisations etc.) are likely to have different objectives and differing expectations. Engagement between stakeholders in an urban water system is not a static point that can be achieved, but a dynamic process that needs to be adapted and changed in response to changing community and government priorities, conditions and personalities (Larson 2010; Larson et al. 2010b).

Multi-stakeholder approaches that involve a variety of agencies, organisations and individuals have been strongly promoted by both governments and international donor agencies, both in developing and in developed countries (Warner 2005). The importance of multi-stakeholder governance processes and structures in the water sector for solving water problems has also been increasingly highlighted in both the academic scholarship and applied arenas (Larson and Stone-Jovicich 2011). Shifts in governance from conventional hierarchies dominated by centralized services providers, towards involvement of new actors

(private companies, NGOs, University and Research Institutes, etc.) have been described in the literature (Dimadama and Zikos 2010). Dimadama and Zikos (2010) argue that emerging informal and voluntary social networks challenge the hierarchical decision making structures often in indirect ("Trojan-horse like") way. New actors bring to the system and acquire new knowledge, knowledge forms and learning processes. Referring back to the theory of adaptive governance (Folke et al. 2005; Pahl-Wostl 2009), such flexible self-organised networks form epistemic communities, and create a transition arena by which innovations and visions are encouraged ('epistemic community' being defined as a large network of people, with a range of special interests, who share a focus and work towards a common knowledge-based goal).

Through the example of Makassar City, we argue that the informal social network structures formed could be interpreted as an epistemic community, by which complex urban water issues are managed in a transition arena comprised by increased links between stakeholders drawn from not only government agencies, but also non-government organisations. That this epistemic community better allows for innovations and visions by all stakeholders is supported by the closer resemblance of informal networks to the 'ideal' network, than to the formal one. However, as Ostrom (2008) argues and warns, polycentric, multi-stakeholder arrangements are not a panacea to help solving complex problems such as urban water management. There are potential benefits and also trade-offs involved in attempting to implement an adaptive approach. Pelling and High (2005b) describe the ideal balance between formal and informal institutions (rules and organisations) as lying at the boundary between stability and instability, regularity and randomness. This place of bounded instability allows novelty to emerge, but as a form that is at least potentially positive and has a sense of continuity with earlier innovations.

One of the motivations of this study was to understand the current context of the urban water management system in Makassar, as a pathway to improved access to clean water and management of impacts of future changes. Compared to the propositions in the adaptive capacity literature, results of this study identified three examples of evidence supporting Makassar's adaptive capacity potential. They are: (i) the existence of a complex informal network structure; (ii) this informal network had less power inequalities, in comparison to the formal network; and (iii) inclusion of non-governmental agencies (such as NGOs and Universities) within the network. However, considering water governance in Indonesia as a whole, in order for Makassar to achieve its actual potential there is still a need for good vertical linkages to higher levels of authority and into political system. Another potential shortcoming is that, if the bridging processes among agencies are created and/or maintained by a small set of key individuals ("champions"), there could be a potential loss of linkages when actors leave the networks. In addition, it must be noted that network "ties" per se will not necessarily be enough to improve governance processes. For the governance processes to improve, central actors in the social networks need to be willing to engage with others; and also be aware that their 'actions' may either benefit or disadvantage others.

6 Conclusion and Recommendations

In this paper, we have presented results of analysis of three types of social networks, formal, informal and ideal, in the context of urban water management in Makassar city, Indonesia. Amongst the 32 government and non-government organisations consulted, six agencies were considered key organisations involved in the city's urban water system. These six key organisations have worked efficiently, based on their legal mandate and authorities and

developed a complex informal network. An analysis of the informal network showed significantly developed and more complex relationships with a variety of other government agencies as well as non-government organisations. The current informal network is much closer to what was perceived by stakeholders as the "ideal" network, than was the formal network. As a result of our research we argue that analyses of informal networks provide a much better representation of the actual state of governance in a water system than an analysis of formal institutional arrangements. This has important implications for understanding the adaptive capacity of the system, which would be underestimated if analysis was based on formal arrangements only.

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