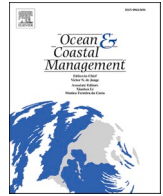




Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: <http://www.elsevier.com/locate/ocecoaman>

Polycentricity and adaptive governance of transboundary marine socio-ecological systems

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ARTICLE INFO

Keywords:

Adaptive governance
Co-management
Polycentricity
Social network analysis
Transboundary marine socio-ecological systems

ABSTRACT

Transboundary marine socio-ecological systems (SESs) are complex and dynamic systems. Enhancing the sustainability of such systems requires adaptive governance supported by polycentric structures. However, adaptive governance of marine SESs across national boundaries can be challenging, as significant differences in institutional arrangements for resource management and adaptive governance capabilities may exist. The limitations of various institutional arrangements and the challenges of adaptive governance across borders are still poorly understood. We offer a comparative study of two marine co-management systems, in southern Kenya and northern Tanzania, which are bound by different legislative environments to elucidate how institutions might limit or enable adaptive governance at the local and transboundary scale. The legislative environment is characterized based on a review of the literature. The structural properties of the co-management systems are examined for evidence of polycentricity using social network analysis. Across the different co-management contexts, we discover similar and distinct institutional opportunities and challenges for adaptive governance. Both co-management regimes foster the participation of diverse actors and multiple interactions. However, both show strong sectoral tendencies and high centrality of government, which can hinder adaptive governance. There are more autonomous decision units in Tanzania's co-management network, hence a more robust social context for polycentricity compared to Kenya. A shift towards enhanced polycentricity to foster adaptive governance of the Kenya-Tanzania transboundary marine SES will require policy frameworks that enhance cross-sectoral integration and create opportunities for multi-stakeholder bridging.

1. Introduction

Governance of transboundary marine socio-ecological systems, both coastal and oceanic, is inherently complex. The complexity often results from multiple jurisdictions and differences in historical, cultural and institutional aspects between states (Levin et al., 2018). The increasing use and loss of marine ecosystems will increase the pressure on already scarce resources. Habitat destruction, biodiversity loss, overfishing and pollution are leading to unprecedented degradation of many transboundary marine systems (Katsanevakis et al., 2015; Vosoghi, 2019; Mason et al., 2020). These declines are driven by increased demand for resources, technological advances, lack of viable alternative livelihoods, and weak governance (Worm et al., 2006; Micheli et al., 2013; Breitburg

et al., 2018). Climate change is likely to exacerbate these pressures, making it more challenging to manage marine resources across boundaries (Hoegh-Guldberg, 2011; Doney et al., 2012; Pecl et al., 2017). The onset of climate change will increase the uncertainty and variability of the availability of marine resources (Sumaila et al., 2011; Brander et al., 2017), and in some cases may irreversibly change specific systems (Wilkinson and Salvat, 2012; Hughes et al., 2018). Institutions that traditionally used to manage transboundary marine systems will find that what worked in the past may no longer apply in the future.

In recent years there has been rising scientific and policy interest in the adaptive governance of social-ecological systems to address complex interactions and to manage uncertainty and periods of change. Adaptive governance has evolved as an analytical approach for understanding

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<https://doi.org/10.1016/j.ocecoaman.2020.105412>

Received 19 February 2020; Received in revised form 26 August 2020; Accepted 30 September 2020

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natural resource governance that takes as its foundation the interdependence of social and ecological systems (Dietz et al., 2003; Folke et al., 2005). Adaptive governance is a continuous problem-solving process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning by doing (Folke et al., 2005). This approach proposes a fundamental paradigm shift from understanding individual parts of the ecosystem to control its variables to understanding the dynamics of the entire socio-ecological system to manage its capacity to absorb changes and respond to uncertainties (Gunderson and Light, 2006; Lebel et al., 2006; Brunner, 2010). Dietz et al. (2003) used the concept of adaptive governance to expand the focus from adaptive management of ecosystems (Lee, 1999), to address the broader social contexts that enable ecosystem management. Adaptive governance requires cooperation at different scales, integration of diverse values, knowledge, actors, and interests to better respond to ecosystem feedbacks at different scales (Folke et al., 2005; Schultz et al., 2015). Moving towards more adaptable forms of governance can help with the management of complex transboundary ocean systems and enhance their resilience (Hughes et al., 2005; Lebel et al., 2006). Adaptive governance systems often self-organize as social networks with teams and actor groups that draw on various knowledge systems and experiences for the development of a common understanding and policies (Folke et al., 2005). The networks facilitate information sharing for adaptive management, thus enhancing the adaptive capacity of socio-ecological systems to large-scale drivers like climate change (Folke et al., 2010).

The network structure supporting adaptive governance is polycentric (Huiteima et al., 2009). The term polycentric is used to describe multiple centres of power or decision making with authority divided amongst bodies with overlapping jurisdictions (McGinnis, 1999; da Silveira and Richards, 2013). The polycentric approach enables adaptive governance of socio-ecological systems by developing structures and processes that match the multi-scale nature of such systems (Galaz and Crona, 2012; Huiteima, 2009; Ostrom, 2010). Collaborative governance of resources or co-management can provide the foundation for polycentric governance since both are grounded in the same fundamental principles: shared power and responsibility between the government and local resource users; the involvement of a wide array of actors and relationships; and bridging scales to link two or more levels of governance (Berkes, 2009; Carlsson and Berkes, 2005). Co-managed systems include governmental and non-governmental actors, forming networks to deal with complex problems in socio-ecological systems (Ansell and Gash, 2008). The adoption of broad-based, co-management regimes with various empowered stakeholders, including the civil society, non-governmental organizations and government agencies, are seen as the foundation steps towards polycentric and adaptive systems (Berkes, 2006; Ebel, 2020).

In most developing countries, co-management of marine resources is viewed as a viable governance option capable of addressing the inadequacies associated with centralized systems (Jentoft, 2005; Guidetti and Claudet, 2010) and building adaptive capacity (Kalikoski et al., 2010). Yet, few of these marine co-management systems are truly polycentric. Few are specifically geared towards facilitating adaptive marine governance (Evans et al., 2011), though many incorporate at least some of the relevant components of polycentric systems (Armitage, 2007; Olsson et al., 2007). Existing studies on co-management as an emerging form of marine resource governance has focused more on analysis at national and sub-national levels (Cinner et al., 2009; Evans et al., 2011), with a more limited examination of their role in transboundary marine systems. It is still less known what type of institutional conditions may limit or enable the transition from co-management regimes to polycentric governance at the local scale to support adaptive governance at the transboundary scale.

This paper contributes to discussions of adaptive governance of transboundary marine socio-ecological systems by examining how institutional conditions may limit or enable transitions of local marine co-management regimes to polycentric governance to support adaptive

governance of transboundary marine socio-ecological systems. We provide a comparative empirical examination of two marine co-management regimes, in southern Kenya and northern Tanzania, which are affected by different political and institutional conditions. We examine the existing institutional environments for co-management in Kenya and Tanzania and the corresponding co-management networks to understand how differences in institutional contexts between countries might affect adaptive governance of shared transboundary marine systems. In the theoretical literature, the essential elements that are the foundation of polycentric governance are identified and described as a conceptual framework to guide the analysis. The comparative design of these two marine co-management systems operating in a shared transboundary marine system but influenced by different legal systems allow us to understand how institutional conditions can affect the transition of marine co-management systems toward polycentric systems to support adaptive governance of transboundary marine systems.

2. Analytical approach

The concept of polycentric governance in the environmental literature was pioneered by work done by Elinor Ostrom (1990) on community-based collective management of natural resources. Ostrom concluded that this form of community self-governance was likely to be sustainable only when nested within a broader system of polycentric governance, one that allowed for multiple mechanisms of collective decision-making and conflict resolution at multiple levels of aggregation (Ostrom, 1990; Andersson and Ostrom, 2008). The theory behind polycentrism is now well-established (McGinnis, 1999; Ostrom, 2010; Carlisle and Gruby, 2017) and the polycentric model has gained traction in environmental resilience and adaptation studies (Djalante et al., 2011; Biggs et al., 2012), because of the suitability of polycentric governance for dealing with complex environmental problems at multiple scales (Ostrom, 2010; Pahl-Wostl and Knieper, 2014; Mahon and Fanning, 2019). However, the concept of polycentric governance still has no definitive definition. Instead, different studies have highlighted different aspects of their structures, processes, or outcomes (Carlisle and Gruby, 2017; McGinnis and Ostrom, 2012; Ostrom, 2010). This study focuses on the structural features of polycentrism. Structure defines how actors and the collective entities they construct are linked together into networks and other forms of interconnections. The basic structural features of polycentric systems include 1) multiple, independent centres of decision-making authority (Andersson and Ostrom, 2008); and 2) overlapping jurisdictions that create partially redundant institutions (McGinnis, 2011b; da Silveira and Richards, 2013).

Various approaches may be useful in understanding the extent to which the structure of resource governance systems is polycentric. Research related to polycentric governance has often drawn on the Institutional Analysis and Development (IAD) Framework (Ostrom and Cox, 2010; McGinnis, 2011b). IAD offers a set of concepts, methods and examples for analyzing who the main actors are, how they are related and how they fit within the larger institutional and environmental context (E. Ostrom, 2009). However, other approaches have recently emerged that may also offer useful insight, from relatively simple forms of stakeholder analysis to more sophisticated methods for social network analysis (SNA) (Mathias et al., 2017). From a network perspective, polycentricity may be analyzed in terms of the number of centres and how they are linked within social networks, including the extent of autonomy (Aligica and Tarko, 2012; Galaz et al., 2012). SNA offers tools for mapping various patterns of nodes and links between organizations (Borgatti et al., 2009), which has considerable potential for a systematic understanding of the options for designing polycentric governance.

In this article, SNA is applied to examine the extent to which marine co-management regimes are polycentric, i.e. their structures are capable of supporting adaptive governance. The structural features of polycentricity are explored using the network perspective to build the analytical framework (Table 1). Using this framework, the study compares local

Table 1
The basic structural features of polycentric systems and the network perspective.

	Description	Network perspective and measures
Structure of polycentric governance	Independence or autonomy in decision making implies that the decision-making centres act on their behalf, without centralized coordination (Ostrom 2010; Huitema et al., 2009). The literature on polycentric governance systems also suggests that modularity or redundancy are structural features of polycentricity that are necessary for responding to change and uncertainty (Biggs et al., 2012; Pahl-Wostl and Knieper 2014b). In polycentric systems, the independent units or modules are not separate from each other but linked through bridging ties (Hahn, 2011; Galaz, Crona, et al., 2012).	Multiple decision units are related to the concept of clustering or modularity (Anderies and Janssen, 2013). Structural modularity can measure the extent to which a network has multiple independent groups or clusters (Janssen et al., 2006). Bridging organizations play brokerage roles in polycentric systems. The central role played by brokers can be examined using centrality measures which examine the extent to which an actor lies on paths between modules or bridges different actors (Freeman, 1978). The more diverse or heterogeneous a network is the more it has many different types of organizations that are multi-sectoral and multi-agency. In this sense, polycentric systems embody institutional diversity which can be measured using network heterogeneity (Plummer et al., 2014). In network terms, overlaps would be best captured by the concept of multiplexity- multiple ways in which actors are connected (Granovetter, 1983). One decision unit viewed as a network might share management functions with another decision unit (network). Hierarchy can be used to measure the extent to which networks form flexible hierarchical structures (i.e. the command structure) (Krackhardt, 1994)
Multiple independent units	Polycentric governance requires a complex combination of multiple levels and diverse types of organizations drawn from public, private and voluntary sectors. Polycentric systems include the idea of multi-sectoral and multi-agency (McGinnis 2011) Overlaps may result from layering of decision-making centres operating at multiple levels or jurisdictions when they share certain functional capacities or areas of responsibility (McGinnis and Ostrom, 2012).	
Overlapping jurisdictions	Polycentric structures include “nested governance” e.g. a hierarchy in which coordination may occur at the larger scales, but flexibility exists for implementation at local scales (Cash et al., 2006; Young, 2006; Berkes, 2002).	

marine co-management systems across the Kenya-Tanzania border, examining their structures for evidence of polycentricity. The Kenya-Tanzania border is an important marine region and provides a challenging case study for identification of polycentricity, specifically due to the differences in marine governance arrangements.

3. Geographical context

3.1. Study location

Kenya and Tanzania share transboundary marine ecosystems (Fig. 1), that harbour important species and habitats (EAME, 2004; Griffiths, 2005). The Kenya-Tanzania transboundary marine system is a biodiversity-rich region, which provides important sources of livelihood for millions of people (UNEP-Nairobi Convention and WIOMSA, 2015). However, marine resources in the border region have been declining because of over-exploitation and mismanagement, threatening the processes and habitats that sustain the transboundary ecosystems (McClanahan et al., 2007, 2008; Wells et al., 2010). The Transboundary Diagnostic Analysis (TDA) (ASCLME/SWIOFP, 2012), revealed that marine resources in the Kenya-Tanzania transboundary marine border face several serious potential threats. The main threats are overfishing and climate impacts (Cinner, 2012; McClanahan, 2009). Fishing is the main livelihood for coastal communities in Kenya and Tanzania and, as the demand for marine resources grows, the marine resources in the Kenya-Tanzania transboundary system may come under pressure from users with conflicting interests (Wanyonyi et al., 2016). There is significant concern about the increasing impacts of climate change on marine ecosystems in both Kenya and Tanzania. These issues with transboundary dimensions have become very prominent in regional discussions (ASCLME/SWIOFP, 2012; UNEP-Nairobi Convention and WIOMSA, 2015). The concerns are not only environmental but also economic and political. Adverse impacts on marine socio-ecological systems in the region will affect fisheries and tourism, two important but highly vulnerable sectors (UNEP-Nairobi Convention and WIOMSA, 2015).

Currently, no common legal framework and no common criteria exist for the management of marine resources and dealing with threats e.g. climate change in the Kenya-Tanzania transboundary marine system. The implications for the development of adaptive governance systems are therefore enormous. The problems related to fishing and impacts of climate change are more transboundary than national in scale, and effective adaptation in the region cannot be effective on a strict country-by-country basis. The current regional initiatives under the aegis of the UNEP-Nairobi Convention, specifically recognizes the importance of cooperation at transboundary scales, and suggest that the best results will be achieved through developing adaptive and resilience-based approaches at national and cross-border levels (UNEP-Nairobi Convention and WIOMSA, 2015). The role of the resilience-based framework for coordinating sectors and countries across the Western Indian Ocean (WIO) regional policies has been included in marine protected area network initiatives (UNEP-WCMC, 2008). This means that countries in the WIO region must work together on regional adaptive strategies and that their capacity to foster adaptive governance is a major element in enhancing the resilience of shared marine socio-ecological systems. Despite the move towards adaptive and resilience thinking in marine resource governance in the WIO region, differences among countries in terms of concrete aspects such as institutional structures for marine governance and how stakeholders are brought into policy and management processes can create tension among member States, which in turn can make transboundary adaptive governance challenging.

3.2. Marine resource governance in Kenya and Tanzania

Marine resource management in Kenya and Tanzania has followed two different paths resulting from different philosophies of governance, socio-economic conditions, and associated policies (McClanahan et al., 2015). The next section describes the institutional frameworks for the

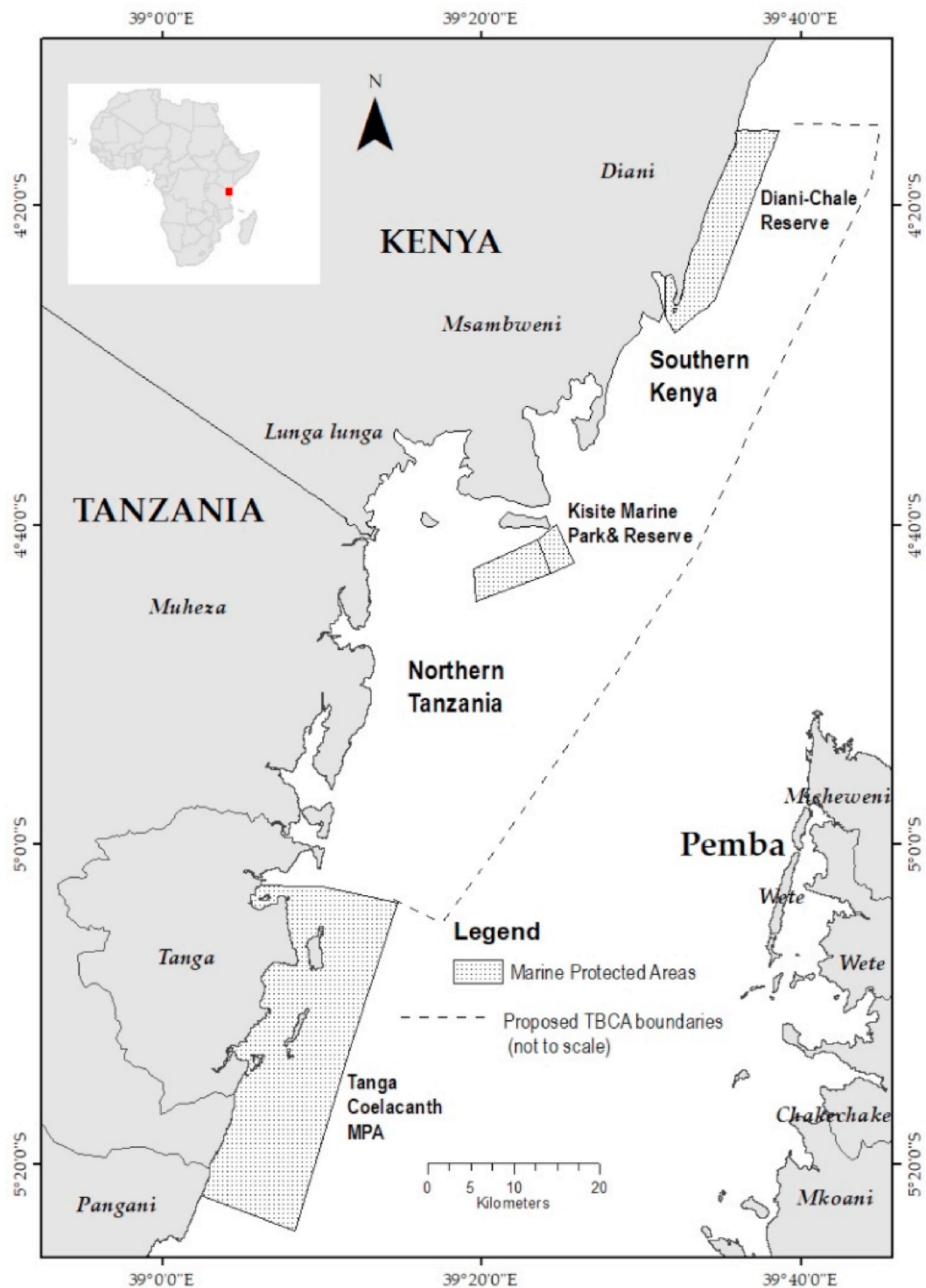


Fig. 1. Map showing the Kenya-Tanzania border region. In this region, there are 3 established marine protected areas (MPAs) managed by government agencies and several fisheries closures that are managed by local communities who are organized as Beach Management Units (BMUs).

co-management of marine resources in Kenya and Tanzania. In both countries, there is a move from the “top-down” approach to more a “lateral” and “bottom-up” approach in the management of coastal and marine resources. The most visible part of this transition is in the building of local organizations of marine resource users and the changes to various legal, institutional and administrative frameworks for marine resource management. Still, there is much variation in the design of these multi-level and collaborative structures between Kenya and Tanzania. This study looks comparatively at collaborative marine

resource management initiatives between Kenya and Tanzania and how the variations may affect adaptively governing their shared transboundary marine system. The next section provides a detailed description of the institutional arrangements in the administration of the co-management of marine resources in Kenya and Tanzania.

3.2.1. Institutional arrangements in the administration of the co-management of marine resources in Kenya

3.2.1.1. Background information. Kenya's marine resource management, including fisheries management, development, conservation and utilization mandates was structured as a top-down system before 2000, solely under government departments (Samoilys and Obura, 2011). A combination of environmental threats and growing evidence of the resulting negative impacts convinced national authorities that it was time to adopt a new management approach, involving communities as partners in management. As a result, there was a paradigm (policy) shift from a government-centred approach to stakeholders (co-management) based approach, from around 2004 (Cinner et al., 2009). The new dimension was taken to ensure that local communities were more involved in the management of coastal and marine resources. In addition, there was an emerging consensus to manage Kenya's coastal and marine resources through an integrated, rather than a sectoral approach (McClanahan et al., 2005).

3.2.1.2. Policy and legislative setting. There are several legal instruments that relate broadly to the co-management of marine resources. These pieces of legislation justify the collaborative management of marine resources in different ways. The Fisheries Act 2016 and the Beach Management Unit (BMU) regulations and their revisions, authorize collaborative management and the designation of fisheries co-management areas (GoK, 2016). The Fisheries Act also empowers local fishers organized as BMUs to work with other stakeholders to create locally agreed-upon fishery management plans that can operate at different geographical scales. A BMU is an organization of fishers, fish traders, boat owners, fish processors and other beach stakeholders who traditionally depend on fisheries activities for their livelihoods. BMUs are the fisheries co-management structure through which community rights over resources are legally established. The Fisheries Act also makes provision for the delegation of "fisheries functions" from the Central government to the County government. The County government regulates BMU activities and also supports activities related to value addition and marketing of fisheries products. Despite the role played by the County governments and the BMUs in the devolved fisheries resource management, the overall control of fisheries resources in Kenya is under the mandate of the Central Government covered by the State Department of Fisheries and the Kenya Fisheries Service. The Forest Act, 2016, also makes provision for the establishment of Community Forest Associations (CFAs) that have empowered the local communities to become custodians of the coastal forests and mangrove resources. The Act allows for community groups to register CFAs and develop management plans for forest resource protection. The Wildlife Management and Coordination Act 2013 acknowledges that communities have a responsibility to safeguard areas inhabited by wildlife through the establishment of community-owned conservancies and sanctuaries (GoK, 2013). Currently, there are several community-based marine resource management initiatives that draw their mandates from the Fisheries, Forest, and Wildlife Acts. The long-term vision of these legislative instruments is to have empowered local communities that work together with the government to sustainably manage marine and coastal resources in their locality.

3.2.1.3. Progress in marine resource co-management in Kenya. With multiple legislations support co-management of marine resources in Kenya, the current institutional design encompasses a wide range of stakeholders in a hybrid system that combines centralized and decentralized, state and community institutions. However, with different government levels and departments pursuing different goals, the coordination and clear division of responsibilities among the institutions at different levels has not been properly defined. Current regulations have many gaps and ambiguities linked to marine resource management due

to unclear criteria related to the use of appropriate indicators/parameters of marine resource status. Furthermore, existing statutes are only partly harmonized with other sectoral strategies (Tuda et al., 2014). Despite the shift from centralized to more inclusive management, emerging collaborative or co-management approaches remain predominantly consultative since the majority of decisions remain with the government agencies that administer different sets of legislation and make decisions on marine resource management through consultative processes with input from resource users and other key stakeholders (Evans et al., 2011).

In the southern coastal area of Kenya, one of the cases examined in this study, collaborative management of marine resources through local user groups, has registered some form of success, particularly where local communities have established community-managed marine areas (Kawaka et al., 2015). Community-managed marine areas take a variety of forms, but those that have existed for the longest time have adopted fishing-gear restrictions and closed areas (McClanahan et al., 2016; Kawaka et al., 2017). However, on Kenya's south coast, adaptive management practices are not rigorously applied partly due institutional, sociocultural, and political factors, that influence both local and state decision making processes (Evans et al., 2011; Kawaka et al., 2017; Tuda et al., 2019). Historical relations between actors, particularly government and local communities, is an important factor mediating the potential for adaptive governance (Evans et al., 2011). In some cases, conflicts between government agencies and communities have resulted in failed attempts to improve marine resource management using marine protected areas, e.g. in the case of the Diani Chale Marine Reserve (Salm and Tessema, 1998).

3.2.1.4. The role of government and links to local actors. The rapid evolution from top-down management to more decentralized systems of marine resource governance took place in this decade, since the promulgation of the Constitution of Kenya 2010. Two levels of government (Central and County), share responsibilities in the management of natural resources including coastal marine resources to ensure their sustainable exploitation, utilization, and conservation. The obligations of the Central government concerning marine resource management include the protection of the marine environment and its resources and establishing a durable and sustainable system of development, in particular, fishing and protection of wildlife. County governments are obliged to implement specific national government policies on natural resources and environmental conservation including, fisheries and forestry. The County governments also coordinate the participation of communities in governance at the local level. They assist communities to develop the administrative capacity for the effective exercise of the functions and powers and participation in governance at the local level, (National Council for Law, 2010). There are National government agencies that have important roles in the management of Kenya's marine resources using a range of approaches and tools, which often overlap (Tuda et al., 2014). The most notable are the Kenya Fisheries Service (KeFS), Kenya Wildlife Service (KWS), the Kenya Forest Service (KFS); the Coast Development Authority (CDA); the Kenya Maritime Authority, the Kenya Ports Authority (KPA), the Kenya Coast Guard Service (KCGS) and the National Environmental Management Authority (NEMA).

3.2.1.5. The knowledge base of co-management in Kenya's south coast. Several research organizations have emerged to support fisher groups and other community organizations involved in marine resource management in Kenya's south coast. Non-governmental organizations (NGOs) and research organizations, including State research organizations and universities, provide the scientific and technical information base on coastal and marine resources in Kenya's south coast. These organizations include: the Wildlife Conservation Society (WCS), the Coastal Oceans Research and Development – Indian Ocean (CORDIO) East Africa, the Coastal & Marine Resource Development (COMRED),

the East African Wildlife Society, the Kenya Marine and Fisheries Research Institute (KMFRI), Pwani University and the Technical University of Mombasa. Several institutions and projects conduct research on coral reefs and associated ecosystems on the south coast of Kenya. The Coral Reef Conservation (CRCP) of the WCS, working closely with the KMFRI and Kenya Wildlife Service (KWS), has carried out a long-term program of monitoring the finfish, urchins and benthic substrate in marine protected and unprotected areas for the last two decades (Muthiga and McClanahan, 1997). WCS has been sharing research findings with local fishers and government agencies through an annual “Fishers Forum” (Cinner, 2006). The annual exchange of information on fish catches and the ecological status of coral reefs helps to shape debates about resource utilization and management options. The forum has also promoted dialogue and exchanges between coastal stakeholders and managers, and between WCS and fishing communities. Research organizations contribute scientific knowledge which when combined with local knowledge complement each other and greatly enhance the co-management planning and management programme.

3.2.2. Institutional arrangements in the administration of the co-management of marine resources in Tanzania

3.2.2.1. Background information. The introduction of co-management and a new policy and legislative environment in the early 1990s marked the departure from centralized management of marine and coastal systems in Tanzania. The government and the international donor community and NGOs have been important drivers of co-management. The main motivations have been problems relating to resource sustainability, equity of access to fishing grounds, and problems with unsustainable fishing practices, e.g. dynamite fishing (Wells et al., 2010). The Government of Tanzania has involved communities in the development of policies, legislation, and regulations as well as in the collaborative management of coastal and marine resources (Verheij et al., 2004; Wells et al., 2010). In many other areas in coastal Tanzania, local-level organizations and fisher representative institutions are well-formed and are active in terms of both advocacy and engagement with government at different levels, and management of their affairs.

There are informal community management schemes in place in many parts of Tanzania's coastline (Makoloweka and Shurcliff, 1997; Jiddawi and Ohman, 2002; de la Torre-Castro, 2012). In the Tanga region, collaborative management areas (CMAs) are the basis for co-management. The Tanga Coastal Zone Collaborative Development Programme (TCZCDP) worked directly with local governments and communities to develop six CMAs (Wells et al., 2007). A key feature of the CMAs is seasonal or temporary reef closures to allow degraded coral reefs time to regenerate or to protect important spawning grounds for certain marine species. The management committee determines which reefs are to be closed and for how long. CMAs are the primary mechanism for stakeholders involvement in marine conservation. Communities at their village level elect representatives to form committees known variably in the literature as Village fishermen committees (VFC), Village Conservation Committee (VCC) or Fisheries Coordination Committee, (FCC). These bodies are involved at different levels of marine resource management that also includes enforcement of environmental laws and regulations. In the CMAs, a system of community sea and land patrols have been created. Some CMAs have also established Advisory Committees which provide for greater involvement of different stakeholders in decision-making.

3.2.2.2. Policy and legislation. There are several sectoral policies and legislations related to co-management of marine and coastal resources in Tanzania. The Local Government (District Authorities) Act (LGA), No 7 of 1982, is the main Act that decentralizes the management of natural resources. The LGA and its revision in the Law 32/2004 on ‘regional governance’ devolves power and responsibilities to provincial and

district levels. Law 32/2004 specifically covers natural resource utilization. The LGA creates district-based local government authorities in Tanzania. Institutions falling under the documentation of the LGA include village councils, district councils, township and municipal authorities. The LGA provides for among other things, the establishment, composition, functions, and legislative powers of the district, township councils, and village authorities.

Besides the LGA, there are other legislations that support the co-management of marine resources. Key among these is the Fisheries Act 2005 and the Marine Parks and Reserves Act, 1994 (Act No. 29 of 1994). The Fisheries Act makes provisions for sustainable resource management through collaboration, including the conservation and protection of fishery resources. The Marine Parks and Reserves Act has the mandate of protecting marine ecosystems and species (URT, 1994). Apart from providing for the protection and conservation of marine resources through marine protected areas (MPAs), the Marine Parks and Reserves Act also has provisions to ensure that communities and local users of resources are facilitated to engage in the planning, development and management of MPAs and that they share in the benefits of the operation of the MPAs. The Forest Act, 2002 (Tanzania), provides for the joint management of mangroves by local communities. Mangrove Collaborative Management Plans (MCMP) are developed to guide the use and conservation of mangrove ecosystems. Village Environmental Management Committees (VEMC) are established to implement the MCMPs. Forest-users have exclusive rights to the products, but the forests remain the property of the Central Government.

3.2.2.3. The role of government and link to local actors. In northern, coastal Tanzania (Tanga region), the process of co-management began around 1994 supported by the Tanga Coastal Zone Conservation and Development Programme (TCZCDP) (Verheij et al., 2004; Wells et al., 2007). The institutional arrangement for joint management of marine resources incorporates multiple levels of government including the Central or National government, the District councils and the Villages governments (Fig. 2). There are legal mechanisms to involve stakeholders at different levels in active decision-making processes. The Village, District, and Ministry levels represent the operational, collective-choice and constitutional rules respectively (Fig. 2). The criteria for decision-making or rules is collaborative. Participatory processes are widely used in the designing, planning and implementation of different fisheries and conservation programmes (Wells et al., 2007). Stakeholders at different levels come together as partners to plan and make rules. Participants involved in action planning include the Villagers, Village Environmental Committees, Village Government (Village Assembly), Central Government, Regional Government, District Council and Departments of Government (Forestry, Fisheries representing district interests, and the respective Ministries (Agriculture, Land etc.) representing national interests (Gustavson et al., 2009).

At the village level, local institutions come together to form the ‘village government.’ The governance structure at the village level is comprised of a Village Assembly, the Village Committees, and the Village Councils. The Village Council is the corporate entity of a registered village. The Village Council undertakes roles including planning and coordinating activities, rendering assistance and advice to the villagers engaged in natural resource management, e.g. forestry. It consists of a chairperson, elected by the Village Assembly and Village Committees that

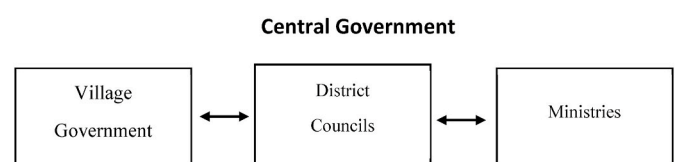


Fig. 2. The different levels involved in marine resource management in the Tanga region, Tanzania. The position of the arrows show the level of interaction.

undertake such matters as planning, finance, economic affairs, social services, security, environment, natural resource protection etc. The role of the Village Assembly includes the development of resolutions relating to fishing practices, forest resource management and use including prescriptions of fees, penalties and fines (Gustavson et al., 2009). The Local Government Act provides for the division of Districts into Wards. As an administrative subdivision between the Village and the District, the Ward reviews the proposed Village Council's projects in its jurisdiction and approves them for passage up the line to the District Development Committee (DDC). The Village Assembly approves decisions made by the Village Governments before they are sent to the Ward levels for subsequent review and approval (which must, in turn, be reviewed and approved at the district level). District Councils supervise the implementation of all plans for economic, commercial, industrial and social development in the Districts, through the appropriate DDCs. Other institutions involved in co-management are the respective Ministries responsible for Fisheries, Lands, Agriculture and Forestry. These connections have been evolving, in many ways, responding to the changing contexts that demand new and more socially acceptable interventions for marine resource governance (Wells et al., 2010).

3.2.2.4. Knowledge base of co-management in the Tanga region. In northern coastal Tanzania (Tanga region), the Tanga Coastal Zone Conservation and Development Programme (TCZCDP) received technical assistance from IUCN and other research organizations to provide scientific information for adaptive co-management (Wells et al., 2007). TCZCDP established partnerships with scientific research institutions such as Coastal Oceans Research and Development in the Indian Ocean (CORDIO) and the Institute of Marine Sciences (IMS) of the University of Dar es Salaam. The programme used participatory monitoring systems, in which the social and ecological monitoring of the Tanga coastal and marine system also involved local communities. Most of the villages in the programme were trained in ecosystem monitoring techniques by different NGOs and research institutions. For example, organizations such as CORDIO trained fishers using local names and languages to monitor underwater fish populations and catches in multiple locations (Obura et al., 2002). One of the innovative and successful monitoring components of the Tanga project is the monitoring of coral reefs by village volunteers. These monitoring programmes provided fishers with a deeper understanding of the impact of fishing on their resources, which in turn helps them adopt appropriate management methods (Wagner, 2007). The village monitoring system was specifically designed to be practical and focused on relatively easy to measure indicators, such as mangrove area replanted or the number of dynamite blasts per month to ensure their sustainability. International NGOs e.g. IUCN, also offered technical support and programme oversight, helping with the training of government staff and villagers and coordination with other institutions. The Tanzania Fisheries Research Institute (TAFIRI) continues to research various aspects of marine and coastal ecology and also provides expert advice to resource managers (Muthiga and McClanahan, 1997).

4. Methodology

A comparative case-study approach was followed in this study to examine the two contrasting marine co-management regimes in southern Kenya and northern Tanzania (Fig. 1). The structures of marine governance systems were explored using the concepts of polycentric governance and formal methods of social network analysis as outlined in Table 1. In this approach, marine co-management systems in southern Kenya and northern Tanzania were conceptualized as actor-networks that were examined for social connections that depict polycentrism. A network is a set of actors or nodes along with a set of ties of a specified type (such as friendship) that link them (Borgatti and Halgin, 2011). Social network analysis offers useful tools for examining structures of

social relationships in networks to uncover connections between entities, (Wasserman and Faust, 1994; Borgatti et al., 2009). The structural properties of the actors' network in the two marine co-management systems were empirically analyzed using techniques in social network analysis to examine how they achieve specific attributes of polycentric systems that are required for adaptive governance. In this analysis, nodes are organizations involved with marine resource use and management in southern Kenya and northern Tanzania that are linked through various activities of co-management including planning, implementation, monitoring and evaluation of management processes.

4.1. Network data

Data collection for this study included questionnaire surveys with key informants from organizations involved in marine resource management in southern Kenya and northern Tanzania. Informants were organizational leaders who had some decision-making authority in their organizations and are valid informers for network studies (Marin et al., 2012). The organizations that took part in the survey were identified from information provided by marine resource managers, (fisheries officers, marine protected area managers, and beach management unit (BMU) leaders), who were initially asked to provide a list of names of the organizations involved in marine and coastal management in their respective management areas. We identified a total of 81 organizations that are related to marine and resource management in the Kenya-Tanzania transboundary marine system (42 from Kenya and 39 from Tanzania). The organizations included government agencies, management organizations, research organizations, NGOs, donor agencies, Universities and resource-user groups. A variety of national government bodies (e.g., Fisheries, Forestry) and local authorities (Local Councils and County Governments) have important roles in the management of the Kenya and Tanzania coastal zone (Verheij et al., 2004; Tuda et al., 2019). The community groups are mainly resource users -fishers groups, beach management units (BMUs) and community conservation groups. These groups are very important in co-management because they are often directly affected by policy decisions. The knowledge needed for management of marine and coastal systems in both southern Kenya and northern Tanzania is partly contributed to and shared by research and academic organizations (Muthiga and McClanahan, 1997; Obura et al., 2002; McClanahan, 2009). These organizations can be regarded as expert groups because they bring scientific knowledge to provide a basis for management decisions. Through the knowledge and expertise they bring, they play an important role in the emergence of knowledge centres and polycentric governance in general (Armitage, 2008).

Questionnaire data was defined by (i) information about ties (i.e., relationships) among organizations and, (ii) organizational attributes (e.g., type of organization, sector affiliations). Information about inter-organizational ties was collected using a socio-metric technique called roster (Wasserman and Faust, 1994; Borgatti and Foster, 2003), whereby respondents were presented with a complete list (roster) of other organizations in the data set and asked to identify those that they have relations with. Separate rosters were developed for Kenya and Tanzania and surveys conducted between April and July 2016. Questions about organizational ties were in two parts. The first part asked respondents to nominate from the roster the key organizations they collaborated with in routine aspects of marine resource management. The second part asked about specific relations in adaptive co-management including relations in: (i) management planning; (ii) implementation of management actions; (iii) social and ecological monitoring; and (iv) assessment and evaluation of management outcomes. The questions on organizational attributes asked respondents to mark from a checklist: (i) organization type (e.g. government, NGO, communities, groups etc.); (ii) sectoral affiliations (fisheries, tourism etc.); and (iii) role in marine resource use and management (conservation, fisheries, tourism etc). Questionnaires were administered using face-to-face interviews and, where informants

were not easily reached, email links with the questionnaire surveys were sent out. Out of the 81 organizations that were identified, individual respondents from 70 organizations were interviewed on both sides of the Kenya-Tanzania border (Kenya $n = 33$ and Tanzania $n = 37$). Network data were processed in UCINET (Borgatti et al., 2002) and Gephi software packages for social network analysis (Bastian et al., 2009).

4.2. Analysis of network data

Relation data were first transformed into adjacency matrices, the entries of which recorded the relationships between pairs of organizations to perform network analysis (Prell, 2011). For each pair of organizations, a 0–1 binary matrix was created. Five adjacency matrices were constructed based on the inter-organization ties. The first matrix was the ‘collaboration in routine aspects of marine resource management’. The other four matrices were for collaboration in specific activities relating to adaptive co-management of marine resources: management planning, implementation of management actions, social and ecological monitoring, and evaluation of management outcomes. The matrices were used to perform different levels of network analysis, i. e., node-level and whole network level, (Borgatti et al., 2009), applying network measures described in Table 1.

4.2.1. Assessing multiple centres of decision-making authority

The extent to which the marine governance systems have multiple independent units of authority that are linked and also diverse was measured using network measures of network modularity, centrality, and heterogeneity (Table 1). The modularity of a network is the extent to which the network is composed of more or less separated sub-networks (Gonzales and Parrott, 2012). Most methods for measuring modularity fall into two main categories called ‘agglomerative’ and ‘divisive’, and involve measures of ‘clustering’, often done through a ‘hierarchical clustering’ procedure, or dendrogram, ‘clique’ and ‘blockmodeling’ (Scott, 2000). The goal of these metrics is to measure the degree of network partitioning, to quantify to what extent a network is built up from smaller, separated subsystems. In this study, the community detection method developed by Blondel et al. (2008), was used to measure modularity. This method looks for communities that are more densely connected than the rest of the network. Networks were examined for optimal modularity by comparing values of calculated modularity to values from a randomized graph with the same number of nodes and the same degree sequence (Bastian et al. 2009). Higher network modularity relative to those of randomly generated networks shows the occurrence of more significant groupings or clusters (Newman, 2006).

The presence of actors who connect different modules was examined using network metrics of betweenness centrality (Everett and Borgatti, 2005). Betweenness calculates the number of shortest paths that run through a network, indicating power and importance for connecting others in the network who were not otherwise connected (Prell, 2011). Betweenness centrality can provide insights into polycentricity when examined across jurisdictional levels. In this analysis, we are looking for organizations that occupy bridging positions in the two co-management networks. A bridging organization is defined here as an entity that connects different participants or groups through some form of strategic bridging process (Crona and Parker, 2012). Research organizations and NGOs have been shown to play important bridging roles in fisheries co-management by providing resources and information to resource users and government agencies (Gelcich et al., 2012; Berdej and Armitage, 2016). In the context of transboundary resource management, research NGOs and research organizations including universities can facilitate information sharing between co-management systems. Research organizations with high betweenness centrality can play a key role in bridging other actors and having significant control over the flow of resources and information within a network (Bodin et al., 2006; Bodin and Crona, 2009). We examined whether the scientific organizations in the networks (research NGOs, Universities) act as bridging

organizations.

To calculate the diversity of actors in the networks, the network measure of heterogeneity was used. Diversity of actors refers to the participation of actors from different backgrounds or sectors (Pittman et al., 2015). Attribute data of organizations (sector affiliations and organization types) were used as indicators of diversity (Carlsson and Sandström, 2008). Organizations were categorized into seven sectors (Fisheries, Conservation, Maritime Operations, Tourism, Commerce, Forestry and Government administration) and seven organization types (National Government, Local Authority, Community-based Organizations, Local NGO, Regional NGOs, International NGOs and Private enterprises) before examining their distribution in the networks using Blau’s index of heterogeneity (Blau, 1977). According to this method, a network with a greater concentration of actors in a single sector and a greater concentration of actors of a particular organizational type will have relatively low Blau-score (low heterogeneity, approaching zero), whereas a network with evenly spread actors across sector and organization type will generate higher Blau-score.

4.2.2. Assessing overlapping jurisdictions

The extent to which networks showed overlapping jurisdictions was assessed by examining network multiplexity. Flexible hierarchical structures were assessed by examining network hierarchy. Network multiplexity is a structural property of network ties that entails the existence of more than one type of relationship between two actors (Wasserman and Faust, 1994). Multiplex networks exist when actors are connected through more than one type of socially relevant tie (Simpson, 2015). Analysis of network multiplexity involved exploring how organizations were simultaneously embedded in the adaptive co-management networks – planning, implementation, monitoring and evaluation networks. Calculation of multiplexity followed three steps: (i) summing the 0–1 binary matrices linearly for planning, implementation, monitoring and evaluation that have been described in section 4.2; (ii) calculating the number of actual multiplex ties against the number of possible multiplex ties in the resulting valued matrix; and (iii) calculating the frequency of overlap of the actual multiplex ties.

The extent to which the networks were hierarchical was examined using the Graph Theoretical Dimensions (GTD) suggested by Krackhardt (1994) for describing informal social structures. The GTD theory specifies four independent graph theoretical measures that “establish a pure structure as a standard against which other structures can be compared”. Those measures are (i) connectedness that measures the extent to which a network is just one weak component; (ii) hierarchy that measures the extent to which paths are not reciprocated; (iii) graph efficiency that measures the extent to which the underlying network has redundant edges, i.e. edges whose deletion does not disconnect the component; and (iv) least upper boundedness that measures the extent to which pairs of actors have a unique common superior, (Everett and Krackhardt, 2012). In this theory, social structures are said to be hierarchical in direct proportion to their divergence from the maximal values of those four measures. The specific graph-theoretical form selected as the standard-bearer or model of a pure hierarchy was the “out-tree” (Krackhardt, 1994; Hunter, 2016). Out-trees are defined in graph theory as direct graphs or digraphs whose every point, except for the root, has one arrow directed towards it but may have several emanating from there. The four measures all range from 0 to 1 and an “out-tree” will give a value of 1 on each measure (Krackhardt, 1994). The product of the four measures was used to provide a general look at the command structures in the networks of the two marine co-management systems allowing for comparison between the networks.

5. Results

Fig. 3 provides a visual representation of the actor-networks depicting the two marine co-management systems in southern Kenya and northern Tanzania. The two systems bring together a diverse set of

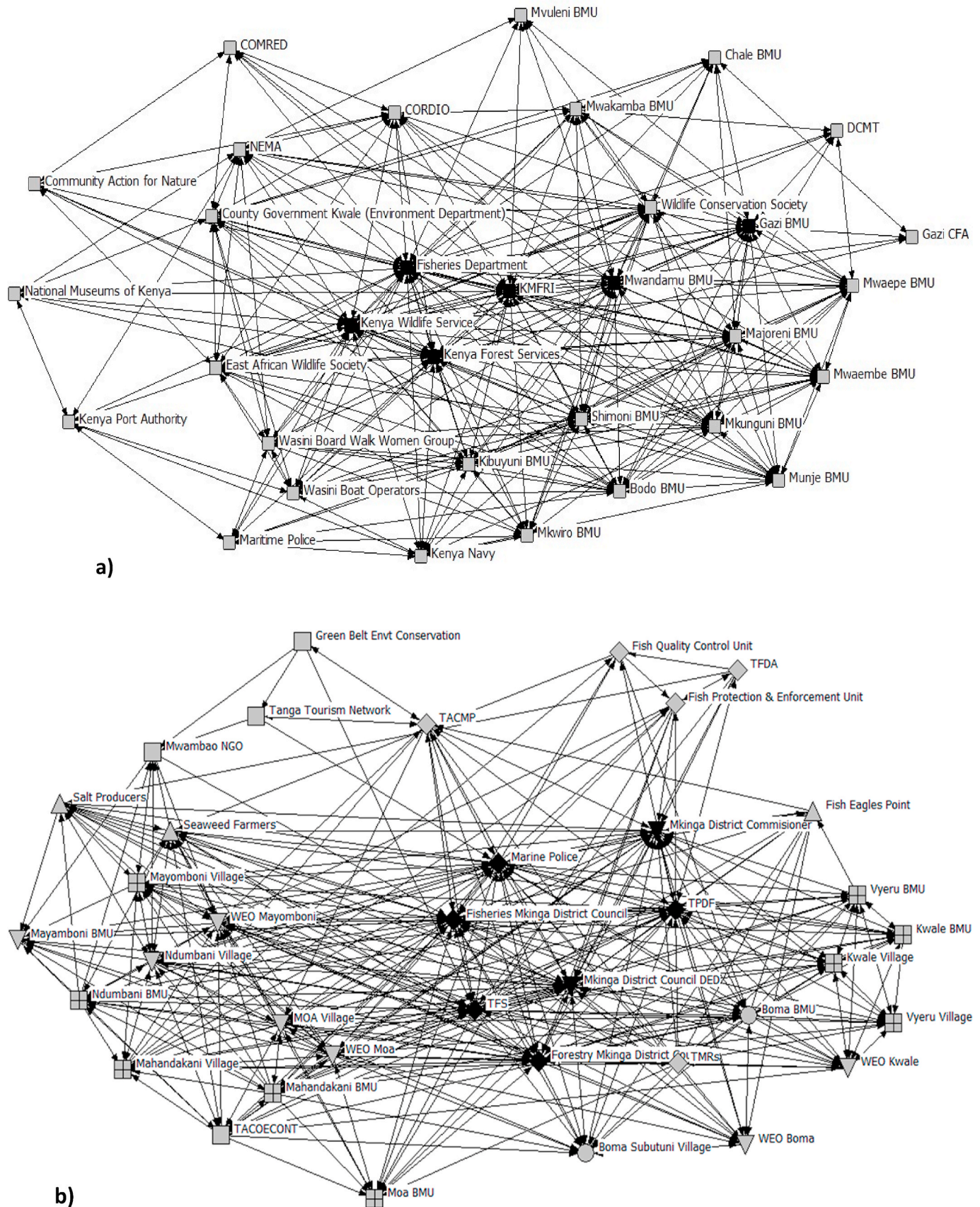


Fig. 3. Topological representation of the networks of marine resource co-management for: (a) southern Kenya and (b) northern Tanzania. The shape of the nodes represents different organizational types. Box = community, Square = NGOs, Diamond = Government Agencies, Down-Triangle = Local government authorities and Up-Triangle = Private entities. This figure also identifies organizations with the greatest "betweenness" measures (black nodes). These organizations serve as bridges between many sub-groups and between organizations.

actors, including government agencies, community groups, and NGOs from the community level to the international level. This illustrates that the governance of marine social-ecological systems in Kenya and Tanzania involves highly complex arrangements and include and affect a wide variety of stakeholders. Fig. 4 shows the proportion of organization types in the Kenya and Tanzania networks. Government agencies and community groups dominate both networks. In Tanzania, compared with Kenya, local authorities are a key players in the co-management process. NGOs and the private sector are the least represented groups in both regimes.

5.1. Polycentricity in marine resource governance in southern Kenya and northern Tanzania

The complex patterns of interactions between actors in the two co-management systems in southern Kenya and northern Tanzania and how the interactions depict the structural features of polycentricity are highlighted in this section. The two marine co-management systems represent a certain level of polycentricity, but also have some common structural deficiencies (Table 2).

5.1.1. Structural modularity of networks

Analysis of modularity shows that both marine co-management networks exhibit modular structures consisting of 3 sub-groups in the Kenyan network and 4 in Tanzania. Both systems showed fewer significant modules (sub-groups) when compared with randomly generated graphs of the same number of nodes and the same degree sequence. We

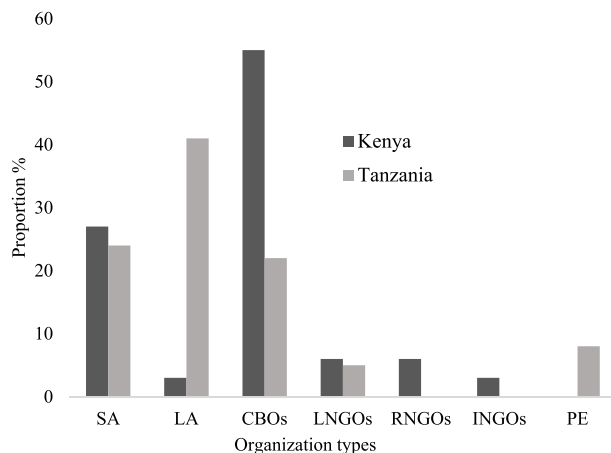


Fig. 4. Comparison of the proportion of organization types in Kenya and Tanzania networks. SA – State Agencies, including State Departments and State research organizations; LA- organizations under Local Authorities, County government and Municipalities; CBOs – community-based organizations, e.g. Beach Management Units; LNGOs – non-government organizations (NGOs) with a local scale of operation; RNGOs – NGOs with working across the Western Indian Ocean region; INGOs – NGOs with an international scope and PE - Private enterprises.

Table 2

Realization and deviations from an ideal polycentric network structure.

Structure of polycentric governance	Indicator of polycentric structure	Comparison of network structures
Multiple independent units	Many independent decision making centres without centralized coordination Bridging ties High stakeholders diversity	Both co-management networks have low structural modularity, hence few independent decision centres. Both networks show the centrality of government agencies with little bridging roles by NGOs, research organizations and community groups. Both networks have high actor- heterogeneity hence diversity, but Tanzania has a higher stakeholders diversity.
Overlapping jurisdictions	Nestedness Functional overlaps	Both networks are non-hierarchical; however, Tanzania's system shows a higher level of flexibility and capacity for self-organization. Both networks show high multiplexity, although in the Tanzania network actors have more diverse roles than in Kenya.

find organizations preferring to be embedded in larger groupings rather than being part of smaller communities. In both networks, the sub-groups varied in size and composition. In the Kenyan system, the largest sub-group had 43% of all organizations in the network, the second-largest sub-grouping had 30%, and the third had 27%. The smallest sub-group was composed mainly of community-based organizations (CBOs), confirming the presence of homophily among community groups, i.e. organizations of the same type interacting among themselves. For Tanzania, the largest sub-group had 41% of all organizations in the network, the second 35%, third 13% and the fourth 11%. The third-largest sub-group had only government organizations; also an indication of homophily, i.e., government agencies in Tanzania tend to form relations with organizations of the same type. The low number of sub-groups in both networks suggests fewer independent units to perform specialized functions. It also suggests fewer inter-module connections or the presence of 'weak' ties.

5.2. Bridging in networks

Analysis of betweenness centrality and in-degree centrality showed that government agencies and local authorities were consistently more central and influential in both networks. In Kenya's network, government agencies had the highest betweenness centrality scores while in Tanzania, both national government agencies and local authorities were important in connecting otherwise disconnected organizations (Fig. 3). In Kenya, the main connector was the Kenya Fisheries Service. Although some community-based organizations (e.g. Mwadamu and Gazi BMUs), showed high betweenness ranking, empirically, they played a lesser role in the network. In Tanzania, there were two government organizations with relatively high betweenness centrality – the Tanzania Forest Service and Mkinga District Council. These organizations help broker relationships and moderate information flow within and across the community and national levels. The results show the importance of government agencies (in Kenya) and local government/council (in Tanzania) as connectors and in building a local-level marine resource governance network.

5.3. Diversity in networks

Both networks showed high heterogeneity, as evidenced by the Blue's heterogeneity scores (Table 3). In both networks, organizations

Table 3

Network properties (for all measures maximum value = 1.0).

Network Characteristics	Measures	Scores	
		Kenya	Tanzania
Diversity	Heterogeneity (sector)	0.67	0.70
	Heterogeneity (organization type)	0.61	0.72
Hierarchy	Connectedness	1.00	1.00
	Hierarchy	0.06	0.05
	Efficiency	0.55	0.51
	LUB	1.00	1.00

were not concentrated around one sector or organization type; otherwise, heterogeneity scores would tend towards zero. The high diversity in both networks creates possibilities for response diversity and builds redundancy that can minimize and correct errors in governance. The Tanzanian network was more heterogeneous than the Kenyan, showing higher diversity in both sector representation and organization types. A higher diversity of actors means that Tanzania has a higher capacity to deal with problems that require diverse ideas and resources.

5.4. Network hierarchy

For the results of GTD, a connectedness score of 1 (Table 3) show that organizations in both Kenya and Tanzania networks were all connected. This suggests that nearly all the organizations were reachable by all others in the networks, though by paths of varying lengths. It also implies that organizations in both networks belonged to some common system. The least upper bound (LUB) score of 1 indicates the extent to which all actors have a common superior. The high connectedness and LUB scores show that all pairs of organizations share a common upstream hub. It signifies the existence of a top command with lower levels of commands. The low hierarchy scores in both networks (Kenya 0.06 and Tanzania 0.05) indicate reciprocated linkages. Concerning efficiency, Krackhardt (1994) expects “a curvilinear relationship between graph efficiency and organizational effectiveness, with the optimum graph efficiency value to lie around 0.5”. Both networks present optimal graph efficiency values (i.e., 0.55 for Kenya and 0.51 for Tanzania). The product of GTD measures shows that neither of the networks meets the conditions of a “pure hierarchy”, although the Kenyan network shows a stronger hierarchy (0.0337) than Tanzanian (0.0277). Thus in relation to adaptive behaviour, Tanzania could have a higher level of flexibility and capacity for self-organization.

5.5. Functional overlaps in networks

Inter-organizational relations in both co-management networks were multiplex, i.e. actors shared multiple links and functions in adaptive co-management. They interacted in the following activities: marine resource planning, implementation of management actions, marine resource monitoring and evaluation of management actions. When the binary matrices of these activities were summed, 363 out of a possible 1056 multiplex ties were present in Kenya's network and 467 out of a possible 1332 in Tanzania. Of the 363 ties in Kenya, 30% represented relationships whereby two organizations are connected by only one activity. In this kind of relation, two organizations interact in only one of the four adaptive co-management activities - either planning, implementation, monitoring or evaluation. Thus, in 70% of the interactions, organizations had relations in multiplex activities, i.e. two activities or more (Fig. 5). Of the 467 ties in Tanzania, 19% represented relations in a

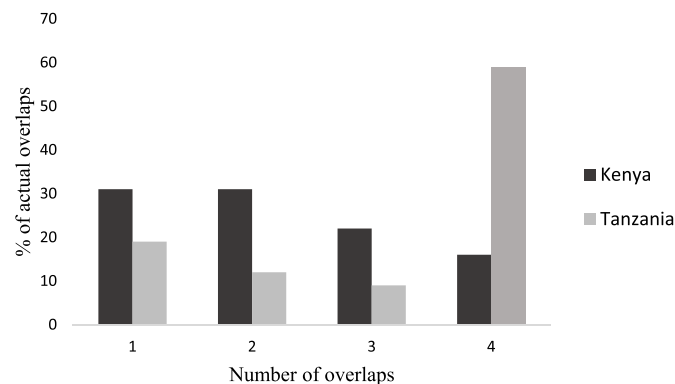


Fig. 5. Comparison of network multiplexity between Kenya and Tanzania networks.

single function and 81% were in multiple activities (Fig. 5). Thus, in Tanzania's marine co-management system, actors play more diverse roles than in Kenya. Stronger multiplexity exists in Tanzania's co-management regimes, i.e. the network shows a much stronger collaboration of diverse stakeholders and greater involvement in adaptive co-management than in Kenya. This also suggests a higher functional overlap in Tanzania's system, hence a higher tendency for jurisdictional overlap.

6. Discussion

Transboundary marine areas are complex social-ecological systems that are characterized by uncertainty and change. Adaptive governance is suggested as a way of handling this complexity (Folke et al., 2005; Berkes, 2006). Polycentric governance provides a feasible way to develop adaptive transboundary marine governance and can prove to be efficient, as it is built in large part on the key role of stakeholders (Ostrom, 2010; Gruby and Basurto, 2014). In our analysis, we use the case of the Kenya-Tanzania transboundary marine system and compare the structures of two adjacent marine resource co-management regimes in southern Kenya and northern Tanzania for polycentricity. These two regimes have to promote polycentrism to increase the prospect of adaptively governing the Kenya-Tanzania transboundary marine socio-ecological system. Kenya and Tanzania have taken different paths in marine resource governance, although marine resource co-management exists in both countries. We compare the inter-organizational networks formed by the two regimes in the process of co-management, focusing on the opportunities and challenges that these two regimes present for adaptive governance of the shared transboundary marine system.

6.1. Opportunities for adaptive governance of the Kenya-Tanzania transboundary marine system

While we emphasize the differences between Kenya and Tanzania in their marine co-management strategies, importantly, there are many structural similarities between the two marine co-management regimes that our study reveals. In both regimes, actors at the local, national and regional levels have come together to improve integration across scales of governance and sectors to provide a more collective response to marine resource management problems. The diversity of social actors interacting in different resource management roles could potentially broaden the collective knowledge base and enhance adaptive governance beyond local administrative levels and jurisdictions. Heterogeneous actors in both regimes may also produce sustainable results because they bring different understandings of the problem and increase the diversity of responses to threats. Hence, they are the key enablers of polycentric governance (Nagendra and Ostrom, 2012). Heterogeneity is likely to promote learning across borders, for example, between scientists and resource users. Tanzania's network shows greater heterogeneity. This can be attributed to the existence of a legal framework which stipulates the participation of stakeholders at multiple levels from the community level to the national level in collaborative marine and coastal management. Thus in Tanzania collective learning can be achieved to a greater extent than in Kenya.

6.2. Challenges for adaptive governance of the Kenya-Tanzania transboundary marine system

Despite both marine co-management regimes having a high diversity of actors, there are structural challenges and impediments to adaptive governance. In both cases, there were few independent decision units when examined using the structural modularity of the networks (the extent to which the system is composed of more or less distinct sub-networks). Thus both regimes have sub-optimal semiautonomous decision-making centres, an important attribute of polycentricity. A

highly modular network composed of completely separated modules or clusters of nodes would make for a more robust polycentric system. In situations where there are only a few autonomous units, the capacity of the networks to assimilate and accommodate change is also reduced (Bodin et al., 2006; Bodin and Crona, 2009). The low modularity in both networks reduces the experiences from different knowledge system sub-groups, which can then lead to limited learning and low adaptive capacity in the regimes (Bodin and Norberg, 2005). In comparison, Kenya's network has lower modularity than Tanzania, meaning fewer independent decision units and hence a smaller capacity for experimentation and learning. The robustness of individual systems to future shocks will, however, depend on other capacities, including their multi-functionality and their ability to efficiently carry the flow of information and resources through the entire network.

The threat of establishing problem-based forums that also promote learning is the issue of homophily, i.e. the tendency of actors to associate with similar others, which was apparent in both regimes. Network analysis shows substantial homophily by sector characteristics, meaning that despite the claims for integrated management, sectoral tendencies in the two systems are still high. When similar individuals associate, this increases redundancy in the knowledge that flows through networks, thus reducing new knowledge and learning (Bodin and Crona 2009). To enhance adaptive governance, actors in both regimes will have to look beyond their homophilous sub-groups for new information and insights. However, the negative effects of homophily on learning can be reduced by the high levels of network multiplexity in both cases. Both marine co-management systems depict multiplex networks where actors are connected through more than one type of activity (e.g. resource planning, monitoring etc.). The multiplex networks can be useful in overcoming sectoral barriers by connecting different administrative jurisdictions and spatial scales (Folke et al., 2005), allowing for the coordinated mobilization of information and resources across spatial scales and reducing uncertainties and structural shocks (Gonzales and Parrott, 2012).

The centrality of government agencies is another common feature of both regimes that can present challenges for adaptive governance. The strong presence of government agencies in both networks and the central role they play in connecting otherwise disconnected actors indicates the social importance of government agencies in brokering relations in both Kenya's and Tanzania's marine governance systems. Empirically Non-Governmental Organizations (NGOs), research organizations, and Community-Based Organizations (CBOs) played a lesser central role in both networks, which limits the mixture of public and private institutional types offering bridging roles. Although a high centrality of government may help solve simple problems, it may not be appropriate for dealing with complexities common in transboundary marine social-ecological systems. The dominance of government agencies also makes both networks vulnerable to fragmentation should government policies change or government departments become dysfunctional. The networks may also become dominated by the supremacy of ideas and interests that stifle dialogue and creative problem solving that underlie adaptive capacity (Adger et al., 2005). The dominance of state agencies can be balanced by the multiplicity of actors participating in governance and by non-government actors taking up more coordination roles. For example, NGOs and research organizations need to develop their capabilities as bridging organizations by coordinating different governance levels, sectors and knowledge systems. This can help in overcoming the constraints of administrative co-management by facilitating knowledge sharing, promoting a shared vision, helping in conflict resolution, and advocating for local empowerment.

With the high centrality of the government agencies in both networks, it was expected that relations among actors would be

hierarchical, i.e. with government agencies being the more important levels. However, network analysis shows that neither of these two networks exhibit a hierarchical organizational structure. From a polycentric perspective, these networks exhibit multi-level connections, where organizations at the top of the hierarchy interact with organizations at lower levels. The linkages also show reciprocity. In such an environment, coordinated actions are more likely to be taken in a multi-level governance environment with feedback that enhances adaptive governance. When faced with a dynamic and unpredictable environment, different levels in the hierarchy can be reached to facilitate quick response (Brondizio et al., 2009). Although the analysis shows that the Kenyan network is more hierarchical than the Tanzanian network, there is no salient difference between the two networks. While Kenya's marine resource system has been perceived as a highly centralized and top-down, the results of this study show a less centralized system indicating that collaborative governance has made progress in Kenya's south coast. Apart from the recent changes in the legal framework, we know little about the factors that improve collaboration in Kenya.

6.3. Polycentric transboundary marine governance in practice

The governance of transboundary marine resources between Kenya and Tanzania has a strong basis, with several widely accepted agreements and conventions (Guerreiro et al., 2010). Yet, in order to evolve and meet the changing needs and emerging challenges such as climate change, transboundary marine resource governance systems must become polycentric, allowing decentralized, and incremental evolution of marine resource governance. In this article, polycentric governance is defined as a case of decentralized governance in which there are multiple independent centres of decision-making (governance centres), with at least partial overlap in jurisdictions. For the current marine regimes to support polycentric transboundary marine governance, they should facilitate and encourage the progressive development of partly overlapping multiple issue-specific governance centres and introduce more non-government bridging organizations to connect the issue-based centres of decision making. Polycentric governance will require that the multiple issues in the Kenya-Tanzania transboundary marine system (UNEP-Nairobi Convention and WIOMSA, 2015), are managed by separate issue-specific forums, led by the active actors thereof, who would create rules for those issues and possibly monitor their application.

Transboundary marine resource governance would thus be the aggregate of different decentralized systems of governance with sufficient autonomy, and that can be updated to adapt to changes flexibly. This can be achieved by encouraging broader participation of marginalized groups in the existing marine co-management systems and also through the facilitation of new group activities. Each governance centre in the co-management systems should have a forum comprised of the relevant stakeholders and experts. Reducing homophilous tendencies in such forums might require that actors who are excluded from such sub-groups are identified and engaged in participatory processes within the sub-groups. The dominance by a few central organizations in the two co-management regimes also need adjustments. Other entities such as NGOs can also play bridging roles to enhance cross-scale interactions that are required for adaptive co-management to support adaptive governance of the transboundary system. Private actors should also take part in the governance of issue-areas in which they are active.

The aggregate of all the diverse decision-making centres drawn from both co-management regimes can create a transboundary co-management system that is polycentric in nature. As the analysis reveals, in both Kenya and Tanzania marine resource governance is already showing attributes to become polycentricity. The above

description is one possible way in which the Kenya-Tanzania transboundary marine regime polycentric structure can appear, but not the only possible way. There is no one strategy and no one way for building systems of polycentric ordering (Ostrom, 2010). Thus we cannot expect such systems either to be constructed or to work in only one way. A polycentric structure of transboundary marine resource governance may eventually take another form, but the basic features of polycentricism are likely to be maintained.

6.4. Study strengths and limitations

The approach followed in this study to assess polycentricity in marine co-management systems in Kenya and Tanzania is practical and has broad applicability. The results demonstrate how a polycentric analysis of governance systems can evaluate the capacity for adaptive governance in local marine governance regimes. It also identifies the reforms that may be required to progress toward more adaptive forms of governance. However, multidimensionality is the main challenge which hinders the practical application of the concept of polycentric governance as an analytical construct. The multiple dimensions pose specific difficulties related to what is measured and how it is measured. It is therefore difficult to interpret whether the current levels of polycentrism and capacity for adaptive governance in the studied systems are optimal. This approach also does not account for the temporal dimension of resource governance, noting that relationships between actors in natural resource governance regimes are dynamic. Focusing only on a particular point in time is therefore likely to provide a partial bias and possibly misleading view of future polycentrism and capacity for adaptive governance. Future research could use stochastic actor-based models (Snijders et al. 2010) that can represent a wide variety of influences on network change, and allow to estimate parameters expressing such influences and test corresponding hypotheses to improve our understanding of regime dynamics.

7. Conclusion

This study shows that local marine co-management systems in southern Kenya and northern Tanzania deviate from an ideal type of polycentricity in several ways. The two marine co-management regimes will need to resolve some structural issues to be able to support the adaptive governance of the Kenya-Tanzania transboundary marine socio-ecological system. To transition to polycentric governance, multiple centres of decision-making that are connected through processes of cooperative learning will need to be established. Policy reforms are needed to enable marine resource management to be carried out simultaneously and autonomously in multiple decentralized systems, especially when the scale of joint management expands from local to transboundary. While building decentralized systems, the existence of sectoral tendencies and dominance by state agencies needs to be considered as this may affect both adaptive governance processes and environmental outcomes. In addition to government agencies, creating opportunities for other bridging organizations can improve the interaction between decentralized units to enhance adaptive learning.

Conflict of interest and authorship confirmation

The authors certify that:

1. They have participated in conception, design, analysis of the data, revision and approval of the final version.
2. They have NO affiliation with or involvement in any organization or entity with any financial interest in the subject matter discussed in the manuscript.
3. This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

AT thanks the European Union for the Erasmus Mundus PhD scholarship in Marine and Coastal Management that made this study possible. This research was undertaken with the funding support of the World Wildlife Fund Russell E. Train Education for Nature Program. AT also thanks the Western Indian Ocean Marine Association (WIOMSA), who supported studies on adaptive management in Kenya and Tanzania through the Marine Science Association, Marine Science for Management [grant numbers MASMA/OP/2013/03]. The Australian Research Council supported SK. AN acknowledges Future Earth Coasts, IMBeR and Future Earth Ocean KAN. The authors thank the interviewees for their openness and time.

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