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Role of local communities in the social network of the protected area management

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Abstract

Biodiversity conservation traditionally necessitates setting aside land, which frequently impacts local communities. Although progress has been made on how to optimize this process, conflict frequently emerges when conservation and community goals are at odds. Improving communication and community inclusiveness in decision-making processes is strongly recommended to achieve livelihood goals and conservation outcomes. We used social network analysis to understand how local communities are embedded within the structure and dynamics of stakeholder interactions in Quirimbas National Park (Mozambique). We detected a network of limited cooperation that lacks bidirectional communication, displaying low average knowledge transfer but high bonding across stakeholder groups with similar perceptions. Local communities only interact with the district government and they have a passive voice in the system. A more inclusive network structure is needed so that conservation and community livelihood goals can be achieved.

KEYWORDS

collaborative governance, exponential random graph models, Mozambique, perceptions, protected area, stakeholders

1 | INTRODUCTION

Protected areas (PAs) aim to conserve nature while also being socially and economically inclusive, given that many people may live within their borders (Givá & Raitio, 2017). The traditional top-down approach to PA governance has gradually been replaced by a more decentralized and collaborative approach, whereby multiple interests are considered (Haukeland, 2011) and all stakeholders play an active role in some part of the process (Plummer & Fitzgibbon, 2006). Enhanced inclusion of local communities in the decision-making process underlying PAs has been strongly recommended (Givá & Raitio, 2017), particularly to decrease mismatches in contributions and improve participation and inclusiveness. This collaborative governance model encompassing stakeholders with diverse power, values, and social norms (Byers, 1996) relies on improving cooperation by trust, reciprocity, and shared principles, and it tends to be more successful (Plummer & Fitzgibbon, 2006). Despite these objectives of the "Parks with People" concept (Givá & Raitio, 2017), that is, PAs where local communities live and use the natural resources, implementation has not been smooth. Leading to complex conflicts between conservation and livelihoods (Haukeland, 2011), with issues regarding rights over ownership and management, access to resources, and the role and power of multiple actors being detrimental to program goals (Adams & Hutton, 2007). Such conflicts may arise from a lack of inclusivity and communication between stakeholders (Abukari & Mwalyosi, 2020), as well as the issue of so-called "paper parks" (WWF, 2017), that is, PAs that have official legal status but no management or associated infrastructure, among other factors. Achieving the decentralized governance necessary for collaborative PA oversight is even more challenging when the local communities living inside the park are poor, have a historical and long-established cultural relationship with nature, and depend on subsistence agriculture, so they often perceive conservation as a threat to their livelihoods (Fletcher & Toncheva, 2021). Thus, it is crucial to develop a better understanding of how collaborative and inclusive governance can be achieved so that local communities are represented, heard, and actively participate in decision-making.

Participation of communities in the decision-making processes for PAs has been shown as crucial to raising awareness of environmental issues, increasing social acceptance and positive perceptions of governance (Hatcher et al., 2000), building local management capacity (Beierle & Cayford, 2002), and empowering communities to fulfill their needs (Bulkeley & Mol, 2003; Iannuzzi et al., 2019). A governance setting that encourages participation is likely to promote more complex stakeholder networks (Iannuzzi et al., 2019). Thus, social network analyses, which are widely used in the social sciences to assess the structure and dynamics of social groups, are now being used to determine if behavioral changes impact the effectiveness of conservation interventions (de Lange et al., 2019), to evaluate the adaptive capacity of management measures in relation to environmental changes (e.g., Fischer & Jasny, 2017), to optimize natural resources management (Berardo & Lubell, 2016), and to investigate how governance systems can transition to more collaborative schemes (Rockenbauch & Sakdapolrak, 2017). Social networks depict the interactions among stakeholders communicating with each other, and can be viewed as "pipes" through which information, knowledge, or resources flow (Borgatti & Foster, 2003). In such networks, nodes represent individuals (i.e., senders or receivers), and direct interaction (or a tie) between two nodes is termed an "edge" (Knoke & Yang, 2011). Interactions can be unidirectional or bidirectional, and some measurement of the frequency of interaction (i.e., strength) is typically assigned (Knoke & Yang, 2011). The position of a given individual in the social network defines their role in the flow of information and their social influence and, consequently, the structure of the network (de Lange et al., 2019; Pei et al., 2017). Individuals with more connections in the network (i.e., those who can be considered central, hubs or opinion leaders) play an important role as disseminators and influencers, with individuals connecting two sub-groups or two unconnected nodes in the social network being termed "bridges" (Bodin et al., 2006). Individuals in the network that are highly connected tend to share similar views, perceptions or behaviors, so information between them flows rapidly and they are more likely to contribute to reducing conflict and promoting collective actions (Bodin & Crona, 2009). In contrast, poorly connected individuals tend to represent isolated stakeholders with dissimilar viewpoints, and though they may hamper coordination, they are more likely to accept innovation and new information (Aral & Walker, 2012; de Lange et al., 2019).

For collaborative management systems, the most resilient networks are densely connected (De Vincenzo et al., 2017), heterogeneous (i.e., encompassing diverse stakeholder groups) (Buckingham et al., 2021), and with their central stakeholders displaying cross-group interactions (Ehrhart et al., 2021; Iannuzzi et al., 2019; Rockenbauch & Sakdapolrak, 2017). Applying these concepts to PA decision-making would mean that local communities should be integrated within a PA social network if the PA is to operate as a collaborative management system. Previous research has shown that excluding local communities impairs effective collaborative management of a PA (Crona & Bodin, 2006), despite such communities often having the highest stake and being the most affected (Khumalo & Yung, 2015). Their exclusion may be unintended, arising from limited access to resources, knowledge, and functioning institutions (Wilson et al., 2013), culminating in an inability to participate (Rockenbauch & Sakdapolrak, 2017). Accordingly, distancing communities from PA management may compromise the interests and livelihoods of the local residents, restricting community development (Abukari & Mwalyosi, 2020), and undermining acceptance and implementation of conservation measures (Salerno et al., 2016).

Here, we assess how local communities in Quirimbas National Park (QNP, Mozambique) are embedded within the structure and dynamics of its stakeholder interactions. More specifically we ask: (i) what is the structure and strength of interactions between entities in the QNP network; (ii) which factors most affect the social network structure of QNP; and (iii) how embedded are local communities within the network? We conducted stakeholder surveys to investigate these questions, anticipating that social network structure reflects stakeholder views and would help establish the role of the local communities in this network. We expected that if QNP meets the principles of a well-designed collaborative governance system, then the network should be densely connected, that is, with strong ties between stakeholders, with most groups being central, and communities being well integrated into it. We also expected that stakeholders sharing similar perceptions about the park would exhibit strong cohesion and bidirectional information flow. Our findings contribute to a growing body of knowledge for how to make PA management systems more collaborative and inclusive, adding to the limited number of existing empirical studies on the social network dynamics pertaining to natural resources (Alexander et al., 2015).

2 | METHODS

2.1 | Study system

We studied communities living within and close to QNP (Province of Cabo Delgado, NE Mozambique; −12°30′0 S, 39°24′0 E). The human population ($N = 200{,}000$) in QNP lives in 153 villages, of which 57% live within the park and the remainder in the buffer zone (MITADER, 2012). The QNP governance structure is composed of a participatory management body (QNP Management Council), an advisory body (COMDEQ—Quirimbas Development Committee), the park administration, and the community councils (CCP; Figure 1).

2.2 | Sampling design

We defined stakeholders as actors conducting activities within QNP and/or that are involved in decision-making relating to its natural resources (Greenley & Foxall, 1997). We collected our data in October 2019 through face-to-face semi-structured interviews and virtual e-mail questionnaires. We conducted a pilot study during a seminar in September 2019, when local and national stakeholders were asked to comment and provide feedback on an initial draft of the survey questions. These inputs were incorporated into the final questionnaires. We also allowed for updates during the interview process. Simultaneously, we used the seminar to select stakeholders by means of a snowball sampling method, whereby seminar participants were asked to identify and provide us with the contact information of other potential stakeholders. This approach was also applied during interviews to identify additional stakeholders (Hay, 2010). Regrettably, due to time limitations, it was not possible to interview every potential stakeholder until no new stakeholders could be identified, a strategy often recommended for attaining a saturation curve in the number of interviewees (Hanneman & Riddle, 2005). We adopted the name-generator questionnaire method (de Lange et al., 2019), whereby respondents list the names of people with whom they interact and the frequency of those interactions (i.e., daily, weekly, monthly, or yearly). We used this method to avoid restricting the

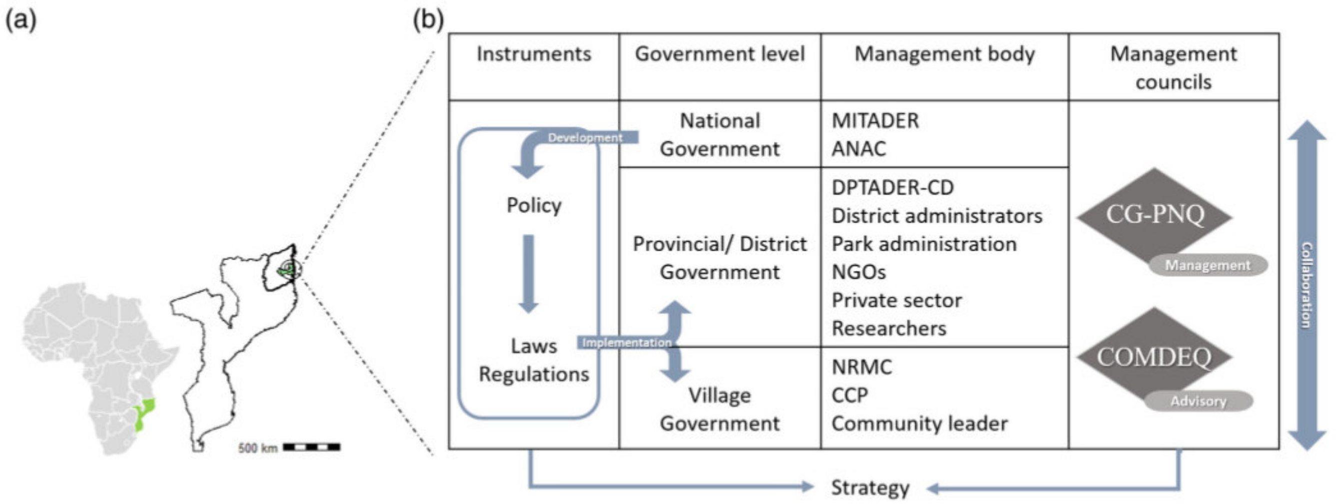

FIGURE 1 (a) Location of Quirimbas National Park (QNP) within Mozambique and the African continent. (b) QNP governance structure, showing legal instruments, management bodies and councils. (MITADER—Ministério da Terra, Ambiente e Desenvolvimento Rural (Ministry of Land, Environment and Rural Development); ANAC—Administração Nacional de Áreas de Conservação (National Administration for Conservation Areas); DPTADER-CD—Direcção Provincial da Terra, Ambiente e Desenvolvimento Rural de Cabo Delgado (Provincial Directorate on Land, Environment and Rural Development for Cabo Delgado); NRMC—Comité de Gestão dos Recursos Naturais (Natural Resource Management Council); CCP—Comité Comunitário de Pescas (Community Fisheries Council); CG-PNQ—Conselho de Gestão do PNQ (Management Board of QNP); COMDEQ—Comité de Desenvolvimento de Quirimbas (Committee for the Development of Quirimbas) answers to a predefined list of stakeholders and so as not to overlook important interactions. The drawback of using this method is that answers are recalled from memory, but biases can be reduced by increasing the number of stakeholders interviewed to obtain a better representation of the network (de Lange et al., 2019). We asked stakeholders about: (i) their perceptions of the challenges or threats to QNP; (ii) the benefits QNP is generating; and (iii) the diversity and frequency of stakeholder interactions (Appendix S1). To obtain information on the diversity and frequency of stakeholder interactions, we built upon the questions provided in Moshier et al. (2019). Participants were informed about the purpose of the study and that participation was voluntary. Furthermore, we highlighted that their names would remain anonymous and that the results of the study would be presented in conferences and academic journals. Before their interviews, the participants were asked to give free and informed consent to their participation in the study. The study was previously approved by the Ethics Committee for the Collection and Protection of Scientific Data ("Comissão de Ética para Recolha e Protecção de Dados de Ciências"—CERPDC) of the University of Lisbon, Portugal.

We surveyed 40 stakeholder entities: QNP managers ($n = 2$), local communities ($n = 14$), nongovernmental organizations ($n = 11$), governmental organizations ($n = 6$), private companies ($n = 2$), tourism operators ($n = 2$), and conservation researchers ($n = 3$).

2.3 | Data analysis

We conducted a preliminary analysis of the survey data using topic modeling to understand the main topics stakeholders perceived as important for park management. We used these topics as predictors of network structure (Section 2.3.1). The results of our topic modeling are presented in the Supporting Information.

2.3.1 | Social network

We used social network analysis to describe the interactions among stakeholder entities involved in managing QNP. In the network, we differentiate between senders, that is, entities represented by an interviewee, and receivers, that is, those named by an interviewee (Fischer & Jasny, 2017). The ties among network nodes, that is, the connections between nodes, were weighted by the interaction frequency on a scale of 1 (yearly) to 4 (daily). We calculated a set of network metrics, namely network density, average degree, and centrality to describe the network structure (Marsden, 2002; Table 1). Analyses were performed using the "igraph" (Csárdi & Nepusz, 2006) and "sna" packages (Butts, 2013) in R (R Core Team, 2019).

We employed exponential random graph models (ERG; Robins et al., 2007) to test if the likelihood of an entity being connected with other entity is higher when entities shared the same view about the park (topic) and belonged to the same stakeholder group. In our models, we considered the number of interactions between two entities as the dependent variable, and the predictor variables were the endogenous and exogenous characteristics of the network (Table 1). First, we identified a well-fitting model by detecting reliably estimated parameters, and then we used simulations to evaluate the robustness of the selected model, that is, how well the model was able to retrieve the structure of the empirical network. We examined the effect of predictor multicollinearity by estimating the variance inflation factor (VIF), with VIF >3 indicating excessive multicollinearity. We calculated VIF >2.15 for all model terms (Table S2), so all variables were included in our model. We used Markov Chain Monte Carlo simulations to perform likelihood-based inference and to estimate goodness-of-fit statistics (Hunter et al., 2008). ERG models were developed in R using the package "statnet" (Handcock et al., 2008).

2.3.2 | Embeddedness of local communities in the network

We assessed network structure and composition of local communities by deriving an egocentric network of those entities from the "full" network, that is, we selected nodes representing local communities and those nodes to which they were directly connected (Everett & Borgatti, 2005). Community nodes could include localities, villages, civil societies (e.g., natural resources committees), or simply the local community in general. We calculated the same metrics as those presented in Table 1 for this egocentric network.

3 | RESULTS

3.1 | Social network

The QNP social network consisted of 70 entities connected by 124 ties (Figure 2). We found that the mean frequency of interactions was 2.1, that is, most of the interactions were on a monthly basis. The density of the network was 0.02, meaning that only 2% of the potential ties are in fact being formed. On average, entities had

TABLE 1 Network descriptor statistics and predictor variables used in the exponential random graph model

	Variables	Definition
Network metrics	Size	Total number of entities in the network
	Diameter	The geodesic distance between all pairs of entities in the network
	Average path length	The average shortest path between two entities
	Density	The number of interactions an entity has, divided by the total of possible interactions an entity could have. Measure of cohesiveness of the network.
	Degree centrality	Number of direct interactions held by each entity. Measures the connectiveness of an entity or network.
	Average degree	The average number of interactions per entity/network
	In-degree centrality	Number of interactions other have initiated with an entity
	Out-degree centrality	Number of interactions an entity has initiated with others
	Betweenness centrality	The number of shortest paths going through an entity.
	Reciprocity	Measure of the likelihood of interactions in a directed network to be mutually linked
	Eigenvector centrality	The degree of connection to other important entities. Measures the influence of an entity.
	Heterophily	Tendency to connect to nodes which have different attributes
	External–Internal (E–I) index	Proportion of ties between groups with different attributes by the proportion of ties within groups with similar attributes. Higher the E–I index, higher the heterophily of the group.
ERG predictors		
Endogenous	Edges	Number of edges in a network. Reveals network cohesion
	Mutual	Tendency for nodes to return the interaction (reciprocity)
	Geometrically weighted outdegree distribution (Gwodegree)	Tendency to receive additional outgoing edges if node already has many edges
	Geometrically weighted edgewise shared partners (Gwesp)	Parameter that represents the number of nodes to whom both nodes in that edge are tied. Capture patterns of closure/clustering
Exogenous	Outdegree centrality (Nodeofactor)	Tendency to receive more outgoing edges based on the specified node attributes
	Homophily (Nodematch)	Tendency to connect to nodes which have similar attributes

three ties (average degree = 3.2), with <5% being bidirectional (reciprocity = 0.048). The network diameter was 20, and the average path length was 2.78. The average likelihood that information created anywhere in the network reached an entity was 9% (degree centrality = 0.09), with the probability of a node receiving information being 16% (in-degree = 0.16) and to provide information it was 12% (out-degree = 0.12). We identified that QNP managers, NGOs (WWF and OIKOS) and the district government exhibited the highest degrees of centrality (Figure 2a). QNP managers, NGOs, and the private sector displayed the highest out-degree centrality (Figure 2c), and the district government, communities, and NGOs presented the highest in-degree centrality (Figure 2b). We also detected very low betweenness centrality (betweenness centrality = 0.06), indicating that the QNP social network has a low number of nodes that work as bridges. The main bridge entities were QNP managers, followed by three NGOs (Aga Khan, WWF, and OIKOS) and the conservation researchers (UniLúrio) (Figure 2d). Lastly, the nodes with the highest eigenvector-centrality, that is, those connected to very influential nodes, were the QNP managers, WWF, and OIKOS, as well as the district government. The nodes of conservation researchers, the private sector and communities were also influential (Figure 2e), but not to the same degree as the QNP managers, NGOs, and district government. The External–Internal (E–I) Index was 0.48, meaning that interactions were stronger between stakeholder

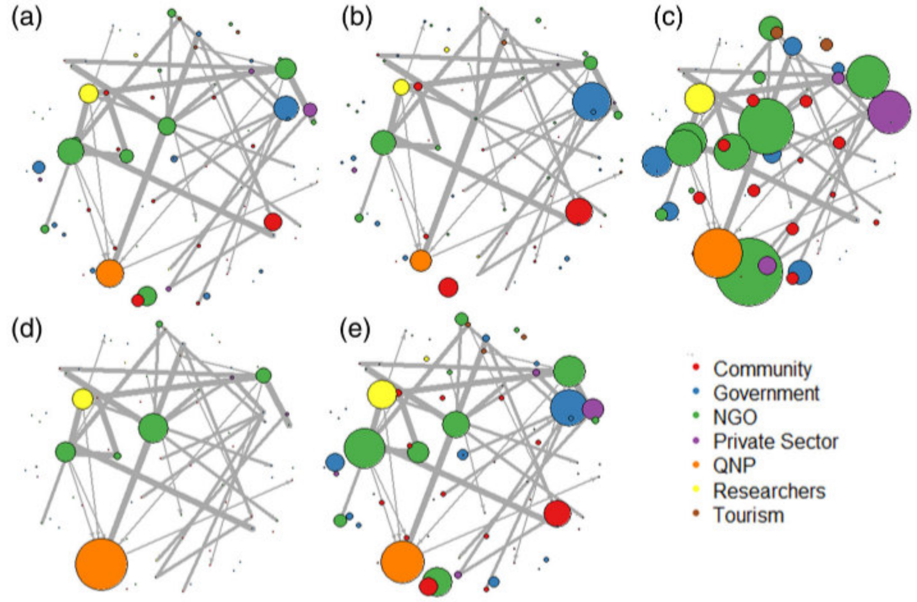

FIGURE 2 Quirimbas National Park stakeholder network, in which each node represents an entity from a stakeholder group (represented by different colors). We mapped the network so that nodes are symbolized according to the type of stakeholder group to which the entity belongs. We only display the nodes with a frequency greater than the mean frequency of the network. Node size represents (a) degree centrality, (b) in-degree centrality, (c) out-degree centrality, (d) betweenness centrality, and (e) eigenvector centrality. Tie width represents interaction frequency (thickest—daily interactions; thinnest—yearly interactions). The arrow represents the direction of the interaction (i.e., unidirectional or bidirectional)

TABLE 2 Exponential random graph model results for the likelihood of interactions established between entities of different stakeholder groups

Predictor variables	Coefficient	Std. error	*p*-value	OR (95% CI)
Edges	−3.86	0.18	<.001	0.02 (−4.20, −3.51)
Gwodegree	−2.84	0.41	<.001	0.06 (0.53, 1.22)
Gwesp	0.88	0.18	<.001	2.41 (−3.66, −2.03)
Nodeofactor: Topic cluster 2	0.39	0.12	.001	1.48 (0.15, 0.63)
Nodeofactor: Topic cluster 3	0.24	0.33	.47	1.27 (−0.41, 0.89)
Nodeofactor: Topic cluster 4	0.66	0.24	.005	1.93 (0.19, 1.13)
Nodematch: Topics	0.56	0.22	.01	1.76 (0.13, 1.01)
Nodematch: Stakeholder group	−0.29	0.23	.23	0.75 (−0.75, 0.18)
Mutual	0.16	0.63	.79	1.17 (−1.06,1.38)

Note: Edges, reciprocity, geometrically weighted out-degree distribution (Gwodegree), and geometrically weighted edgewise shared partners (Gwesp) are endogenous effects while the node outdegree effects (Topic 2, Topic 3, Topic 4), homophily (Topics), and homophily (Stakeholder group) relate to the exogenous covariates effects on the established interactions. For every tested predictor variable the coefficient value, standard error, *p*-value, odds-ratio (OR), and 95% confidence interval (95%CI) were calculated. The predictor variables are ordered by the magnitude of contribution to the model.

groups (heterophily = 0.74) than within groups (homophily = 0.26).

3.2 | Modeling the stakeholder network

Our ERG model displayed high goodness-of-fit, indicating that the model adequately retrieved the structure of the empirical network (Figure S4). The best model to test if the likelihood of an entity being connected with other entity is higher when entities shared the same view about the park (topic) and belonged to the same stakeholder group (Table 2) had a negative coefficient for edges and a geometrically weighted out-degree, together indicative of a sparse and skewed network in which a few actors have a disproportionately high number of outdegree ties.

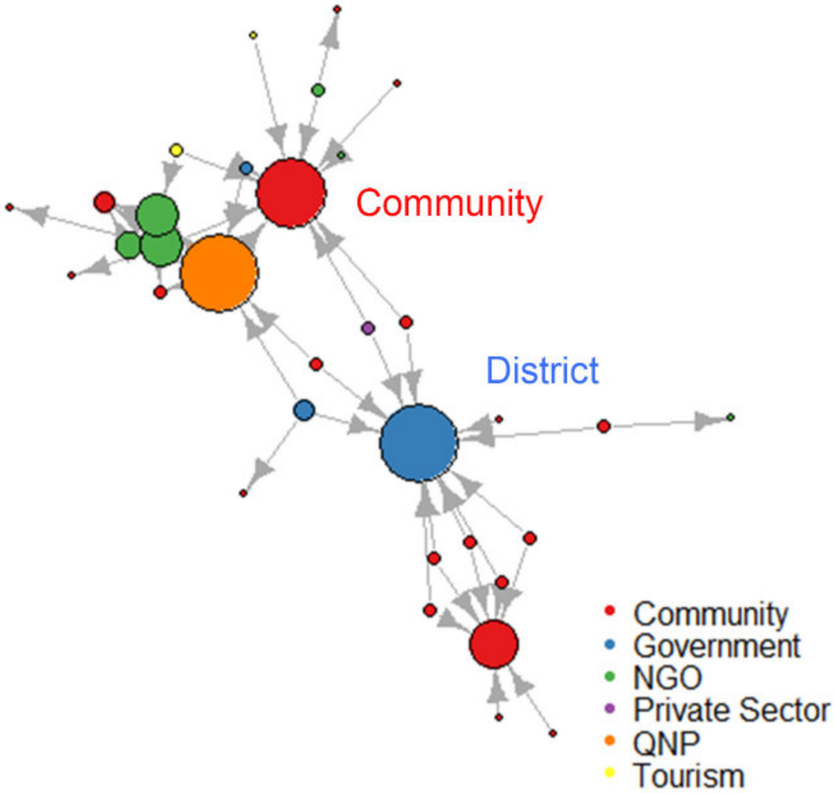

FIGURE 3 Egocentric network for nodes labeled as "Community" in the overall stakeholder network. The nodes represent entities from a stakeholder group (represented by different colors), with nodes identified as "Community" being the "ego nodes" and other nodes being the "alter egos" with first-order interactions with the ego nodes. The width of the ties represents the interaction frequency (thickest—daily interactions; thinnest—yearly interactions). The arrow represents the direction of the interaction (unidirectional or bidirectional)

The structure of the network was also positively influenced by shared partners (Gwesp), capturing the existence of clusters within the network. In addition, the model showed within-topics homophily, implying that entities are strongly and closely connected (all ties are exhibited) when they shared the same view. Lastly, the outdegree of the network was better explained by a positive effect of the topics "Delivery of basic needs services," "Relationship with the Park," and "Management challenges," as well as "Rethink the Park" (topic modeling is presented Appendix S2). The effects of all other factors were not significant.

3.3 | Network embeddedness of local communities

The communities-focused egocentric network included 33 entities and 49 ties, with an average degree of 1.5 ties per entity, and had a diameter of 9 and a density of 0.048. These entities presented a 13% likelihood of accessing information shared in the network (degree centrality), and a very low betweenness centrality of 0.03, evidencing the lack of bridges in this network (Figure 3). Notably, QNP managers and NGOs were peripheral nodes lacking ties with community members, despite QNP managers, the district government, and communities generally being the most central nodes in the overall QNP stakeholder network.

4 | DISCUSSION

We set out to understand the structure of the stakeholder social network of the QNP management system and the placement of local communities within that system. We found local communities to be well integrated in the network, with strong bonding across stakeholders holding similar perspectives about the park. However, despite their central role, local communities mostly acted as information receivers, only interacting with the district government. In general, the QNP stakeholder network was sparse, lacking bidirectional communication, and displaying low knowledge transfer among entities.

The low density of the QNP network, with just 2% of all possible interactions being established, suggests high disaggregation and low connectivity between stakeholders (Plummer, 2009). In fact, very little information flow (9%) reaches the actors of the stakeholder network, perhaps because the large physical distance between entities makes it difficult to meet, even once a month. Nevertheless, we detected information flow between stakeholder groups sharing similar perceptions of the park, despite the expectation that this would only occur in a denser network (Plummer, 2009). These results indicate that the QNP network meets the required design for knowledge sharing between stakeholders (Wölfer et al., 2015). However, this low sharing of knowledge could isolate some groups even further; this could cause some groups to become detached from decision-making, thereby fostering distrust and social and political conflicts (Wölfer et al., 2015), as well as uncooperative behavior (Berardo & Lubell, 2016). In the case of QNP, such detachment does seem to be occurring, as entities already very isolated only have a few interactions with less influential actors (i.e., entities with the lowest eigen-vector centrality also have the lowest degree-centrality, as observed for some communities, NGOs, and tourism operators). If segregated in this way, the likelihood of entities participating in decision-making or being informed about park policies diminishes (Wölfer et al., 2015). Contrary to our expectations, the functional roles of QNP stakeholders had no bearing on communication, as demonstrated by the weak bonding and high bridging characteristics of the network (Plummer & Fitzgibbon, 2006). Bridging emerges in a network when a few entities are markedly more active in the system, such as is the case for the QNP managers, NGOs and the district government. Accordingly, our findings suggest that the QNP network is a low risk system, especially since low risk systems tend to form bridging structures rather than bonding (Berardo & Lubell, 2016). However, for a functional network to persist long-term, bridges still need to be created between entities.

The popular actors in the QNP social network, and consequently those more integrated in the system, are the QNP managers, some NGOs, and the district government. The absence of a single authority figure in the network evidences decentralization and integration of the various stakeholder groups (Dwyer & Hodge, 2016), which is a positive feature. However, the very low average bidirectionality (5%) in this network demonstrates that greater efforts at integration are needed. The ratio of in- and out-degree interactions suggests that local communities exhibit the major mismatches, receiving a reasonable number of interactions but giving too few. In contrast, the QNP managers and NGOs disperse more information in the network, but receive much less. Previous studies have shown that local elites, typically politicians and the private sector, but potentially also park managers and international NGOs, often leave communities badly informed and with a passive role in PA operations (Wertz-Kanounnikoff et al., 2014). From the perspective of QNP, the directionality we observed in information flow limits the capacity of the overall stakeholder network to receive information from its local communities and interact with them. From the perspective of the communities, this lack of information flow is a barrier for their aspirations and needs to be heard and considered. This mismatch could seriously limit the effectiveness of the QNP management plan, possibly impairing acceptance of its implementation and increasing community vulnerability (Le et al., 2012), creating circumstances in which conservation conflicts could arise. Local NGOs are expected to act as bridges between communities and authorities (Gross, 2017), yet they are not fulfilling that role adequately in QNP, potentially due to the short-term nature of their funding and temporary projects (Gross, 2017).

Interestingly, QNP communities mainly communicate with the district government, rendering it the main channel by which information is disseminated from local communities and in line with its expected role (Province et al., 2003). Problems of miscommunication between PA communities and governments have been identified before (Soto et al., 2001), and this issue seems to exist in the QNP network, with its communities expressing many ways by which they feel that communication regarding the park is failing. First, communities feel inadequately informed about park legislation and do not feel integrated in the management of the park, an issue they have in common with other PAs (e.g., Virtanen, 2005; Wertz-Kanounnikoff et al., 2014). Second, communities would like to understand the fate of the 20% of the park revenues that their are legally entitled to receive, i.e. how are these 20% being used and how can communities access it. Only 4 of the 13 villages we visited mentioned receiving a fraction of park revenue on a regular basis. This lack of revenue sharing could have arisen because some local communities lack an organized and formalized natural resource management committee, as required by national law, as well as a lack bank account, which would enable them to receive the revenues they are entitled to (Norfolk, 2004). Furthermore, QNP generates very little revenue (MITADER, 2012), which is insufficient to share with all communities. Alternatively, corruption and vested interests within the local communities may prevent the distribution of the revenue to community members (Grossmann et al., 2020). Thus lack of information, transparency, and tangible benefits from QNP may strongly affect the willingness of its communities to actively engage in the network and participate collaboratively (Ullah & Kim, 2020). Moreover, these impediments may also affect bonding between villages, potentially restricting implementation of the management plan (Alexander et al., 2015).

Despite our finding that QNP communities are somewhat involved in park management, our results should be interpreted with caution. First, we could not interview all stakeholders in the PA, resulting in an incomplete network and nonresponding nodes (i.e., those lacking outgoing ties). Second, we used a recall approach, which could have resulted in misreported or unreported ties (Guerrero et al., 2020). To circumvent this limitation, we used metrics robust to missing data (e.g., in-degree centrality) and robust analysis (ERG; Robins et al., 2007). Third, we assumed that the perceptions of respondents were transmitted as information or knowledge in the network, but we could not validate that assumption. Fourth, our modeling analysis is static, solely representing a snapshot of the QNP stakeholder network (Berardo & Lubell, 2016).

Generally, a primary objective of PA management is to foster a culture of trust and collaboration, in which all stakeholders are actively engaged and involved in a decentralized decision-making process. Theoretically, such a structure would have major benefits in terms of meeting both conservation and livelihood goals, yet in many cases such networks have not been attained. Here, we have shown quite substantial communication flow among stakeholder groups in QNP. Regrettably, information flow is not even throughout the stakeholder network, with some actors, such as the QNP managers and NGOs, being more central, whereas local communities remain peripheral and act as receivers rather than senders of information. Moving forward, although our results indicate that the network structure of QNP stakeholders might possess some of the desired characteristics for protected area management, the fact that there is no flow of information from the communities to the park suggests that there is a need for more inclusivity. For instance, we propose that it will be crucial that NGOs and QNP managers act as stronger bridging entities by facilitating better bidirectional communication regarding rules and revenues of the park. We also suggest that further analyses could improve our understanding of trust and collaboration beyond what is presented in our analysis, and how can they play a role in meeting concurrent goals of biodiversity conservation and improvement of community livelihoods.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

AUTHOR CONTRIBUTIONS

Joana Pereira: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Visualization, Funding acquisition. **Luís Miguel Rosalino**: Conceptualization, Methodology, Writing – review, Supervision, Funding acquisition; **Maria João Santos**: Conceptualization, Methodology, Writing – review, Supervision.

DATA AVAILABILITY STATEMENT

The datasets generated for this study can be made available upon request to the corresponding author.

ETHICS STATEMENT

The authors confirm this material is the authors' own original work, which has not been previously published elsewhere. The paper reflects the authors' own research and analysis in a truthful and complete manner. The paper properly credits the meaningful contributions of coauthors and coresearchers. The results are appropriately placed in the context of prior and existing research. The authors assert that all procedures contributing to this work comply with applicable ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008 and by the Ethics Committee for the Collection and Protection of Scientific Data ("Comissão de Ética para Recolha e Protecção de Dados de Ciências"—CERPDC) of the University of Lisbon, Portugal.

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REFERENCES

Abukari, H., & Mwalyosi, R. B. (2020). Local communities' perceptions about the impact of protected areas on livelihoods and community development. *Global Ecology and Conservation*, *22*, e00909. https://doi.org/10.1016/j.gecco.2020.e00909

Adams, W. M., & Hutton, J. (2007). People, parks and poverty: Political ecology and biodiversity conservation. *Conservation and Society*, *5*(2), 147–183.

Alexander, S. M., Armitage, D., & Charles, A. (2015). Social networks and transitions to co-management in Jamaican marine reserves and small-scale fisheries. *Global Environmental Change*, *35*, 213–225. https://doi.org/10.1016/j.gloenvcha.2015.09.001

Aral, S., & Walker, D. (2012). Identifying influential and susceptible members of social networks. *Science*, *337*(6092), 337–341. https://doi.org/10.1126/science.1215842

Beierle, T. C., & Cayford, J. (2002). *Democracy in practice: Public participation in environmental decisions*. Washington, DC.

Berardo, R., & Lubell, M. (2016). Understanding what shapes a polycentric governance system. *The American Society for Public Administration*, *76*(5), 738–751. https://doi.org/10.1111/puar.12532

Bodin, O., & Crona, B. (2009). The role of social networks in natural resource governance: What relational patterns make a difference? *Global Environmental Change*, *19*(3), 366–374. https://doi.org/10.1016/j.gloenvcha.2009.05.002

Bodin, O., Crona, B., & Ernstson, H. (2006). Social networks in natural resource management: What is there to learn from a structural perspective? *Ecology and Society*, *11*(2), r2.

Borgatti, S. P., & Foster, P. C. (2003). The network paradigm in organizational research: A review and typology. *Journal of Management*, *29*(6), 991–1013. https://doi.org/10.1016/S0149-2063(03)00087-4

Buckingham, K., Arakwiye, B., Ray, S., Maneerattana, O., & Anderson, W. (2021). Land use policy cultivating networks and mapping social landscapes: How to understand restoration governance in Rwanda. *Land Use Policy*, *104*, 104546. https://doi.org/10.1016/j.landusepol.2020.104546

Bulkeley, H., & Mol, A. P. J. (2003). Participation and environmental governance: Consensus, ambivalence and debate. *Environmental Values*, *12*(2), 143–154. https://doi.org/10.3197/096327103129341261

Butts, C. T. (2013). SNA: Tools for Social Network Analysis, R Package Version 2.3-2.

Byers, B. A. (1996). Understanding and influencing behaviors in conservation and natural resources management. In *African Biodiversity Series*, *No.4*. Biodiversity Support Program

Crona, B., & Bodin, Ö. (2006). What you know is who you know? Communication patterns among resource users as a prerequisite for co-management. *Ecology and Society*, *11*(2), 7. https://doi.org/10.5751/ES-01793-110207

Csárdi, G., & Nepusz, T. (2006). The igraph software package for complex network research. *International Journal of Complex Systems*, *1695*(5), 1–9.

de Lange, E., Milner-Gulland, E. J., & Keane, A. (2019). Improving environmental interventions by understanding information flows. *Trends in Ecology and Evolution*, *34*(11), 1034–1047. https://doi.org/10.1016/j.tree.2019.06.007

De Vincenzo, I., Giannoccaro, I., Carbone, G., & Bari, P. (2017). How social network features and organizational structure impact team performance in uncertain environments. *Emergence: Complexity and Organization*, *19*(2), 1–19. https://10.emerg/10.17357.03a0541223537bc7607aa7035475ba39

Dwyer, J., & Hodge, I. (2016). Governance structures for social-ecological systems: Assessing institutional options against a social residual claimant. *Environmental Science and Policy*, *66*, 1–10. https://doi.org/10.1016/j.envsci.2016.07.017

Ehrhart, S., Stühlinger, M., & Schraml, U. (2021). The relationship of stakeholders' social identities and wildlife value orientations with attitudes toward red deer management. *Human Dimensions of Wildlife*, *27*, 69–83. https://doi.org/10.1080/10871209.2021.1885767

Everett, M., & Borgatti, S. P. (2005). Ego network betweenness. *Social Networks*, *27*(1), 31–38. https://doi.org/10.1016/j.socnet.2004.11.007

Fischer, A. P., & Jasny, L. (2017). Capacity to adapt to environmental change: Evidence from a network of organizations concerned with increasing wildfire risk. *Ecology and Society*, *22*(1). https://doi.org/10.5751/ES-08867-220123

Fletcher, R., & Toncheva, S. (2021). The political economy of human-wildlife conflict and coexistence. *Biological Conservation*, *260*, 109216. https://doi.org/10.1016/j.biocon.2021.109216

Givá, N., & Raitio, K. (2017). 'Parks with people' in Mozambique: Community dynamic responses to human–elephant conflict at Limpopo National Park. *Journal of Southern African Studies*, *43*(6), 1199–1214. https://doi.org/10.1080/03057070.2017.1374810

Greenley, G. E., & Foxall, G. R. (1997). Multiple stakeholder orientation in UK companies and the implications for company performance. *Jornal of Management Studies*, *34*(2), 259–284. https://doi.org/10.1111/1467-6486.00051

Gross, E. (2017). Tackling routes to coexistence human-elephant conflict in sub-Saharan Africa (Report). *CIRED - Open Access Proceedings Journal*, 1–67. https://doi.org/10.13140/RG.2.2.24301.33767

Grossmann, C. M., Patkó, L., Ortseifen, D., Kimmig, E., Cattoen, E. M., & Schraml, U. (2020). Human-large carnivores co-existence in Europe – A comparative stakeholder network analysis. *Frontiers in Ecology and Evolution*, *8*(266), 1–18. https://doi.org/10.3389/fevo.2020.00266

Guerrero, A., Barnes, M., Bodin, Ö., Chadès, I., Davis, K., Iftekhar, M., Morgans, C., & Wilson, K. (2020). Key considerations and challenges in the application of social-network research for environmental decision making. *Conservation Biology*, *34*(3), 733–774. https://doi.org/10.1111/cobi.13461

Handcock, M. S., Hunter, D. R., Butts, C. T., Goodreau, S. M., & Morris, M. (2008). statnet: Software tools for the representation, visualization, analysis and simulation of network. *Journal of Statistical Software*, *24*(1), 1548–7660. https://doi.org/10.18637/jss.v024.i01

Hanneman, R., & Riddle, M., (2005). *Introduction to social network methods.*. University of California, Riverside: Riverside, CA. http://www.faculty.ucr.edu/~hanneman/nettext/

Hatcher, A., Jaffry, S., Thebaud, O., & Bennett, E. (2000). Normative and social influences affecting compliance with fishery regulations. *Land Economics*, *76*(3), 448–461. https://doi.org/10.2307/3147040

Haukeland, J. V. (2011). Tourism stakeholders' perceptions of national park management in Norway. *Journal of Sustainable Tourism*, *19*(2), 133–153. https://doi.org/10.1080/09669582.2010.517389

Hay, I. (2010). *Qualitative research methods in human geography*. Oxford University Press.

Hunter, D. R., Handcock, M. S., Butts, C. T., Goodreau, S. M., & Morris, M. (2008). ergm: A package to fit, simulate and diagnose exponential-family models for networks. *Journal of Statistical Software*, *24*(3), nihpa54860. https://doi.org/10.18637/jss.v024.i03

Iannuzzi, G., Santos, R., & Mourato, J. M. (2019). The involvement of non-state actors in the creation and management of protected areas: Insights from the Portuguese case. *Journal of Environmental Planning and Management*, *63*(9), 1674–1694. https://doi.org/10.1080/09640568.2019.1685475

Khumalo, K. E., & Yung, L. A. (2015). Women, human-wildlife conflict, and CBNRM: Hidden impacts and vulnerabilities in Kwandu Conservancy, Namibia. *Conservation and Society*, *13*(3), 232–243. https://doi.org/10.4103/0972-4923.170395

Knoke, D., & Yang, S. (2011). *Social network analysis*. SAGE Publications.

Le, S., Murwira, A., Mukamuri, B., Czudek, R., Taylor, R., & La, M. (2012). Human wildlife conflicts in southern Africa: Riding the whirl wind in Mozambique and in Zimbabwe. In *The importance of biological interactions in the study of biodiversity*. London: IntechOpen. https://doi.org/10.5772/23682

Marsden, P. V. (2002). Egocentric and sociocentric measures of network centrality. *Social Networks*, *24*(4), 407–422. https://doi.org/10.1016/S0378-8733(02)00016-3

MITADER. (2012). *Plano de Maneio 2011–2021 Parque Nacional das Quirimbas*. Ministry of Tourism

Moshier, A., Steadman, J., & Roberts, D. L. (2019). Network analysis of stakeholder community combatting illegal wildlife trade. *Conservation Biology*, *33*(6), 1307–1317. https://doi.org/10.1111/cobi.13336

Norfolk, S. (2004). *Examining access to natural resources and linkages to sustainable livelihoods: A case study of Mozambique*. FAO LSP WP 17, Access to Natural Resources Sub-Programme.

Pei, S., Morone, F., & Makse, H. A. (2017). Theories for influencer identification in complex networks. In *Complex spreading phenomena in social systems: Influence and contagion in real-world social networks*. Springer International Publishing.

Plummer, R. (2009). The adaptive co-management process: An initial synthesis of representative models and Influencial variables. *Ecology and Society*, *14*(2). https://doi.org/10.5751/ES-03130-140224

Plummer, R., & Fitzgibbon, J. (2006). People matter: The importance of social capital in the co-management of natural resources. *Natural Resources Forum*, *30*(1), 51–62. https://doi.org/10.1111/j.1477-8947.2006.00157.x

Province, B. K., Nam, V., Lan, H., Castella, J., & Novosad, P. (2003). Village communication networks and implications for agricultural extension in the northern mountains of Viet Nam . A case study in Ngoc Phai Commune, Cho Don District, *Bac Kan* Province, Viet Nam. *SAM Paper Series*, *18*.

R Core Team. (2019). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.

Robins, G., Snijders, T., Wang, P., Handcock, M., & Pattison, P. (2007). Recent developments in exponential random graph (p*) models for social networks. *Social Networks*, *29*(2), 192–215. https://doi.org/10.1016/j.socnet.2006.08.003

Rockenbauch, T., & Sakdapolrak, P. (2017). Social networks and the resilience of rural communities in the Global South: A critical review and conceptual reflections. *Ecology and Society*, *22*(1). https://doi.org/10.5751/ES-09009-220110

Salerno, J., Borgerhoff Mulder, M., Grote, M. N., Ghiselli, M., & Packer, C. (2016). Household livelihoods and conflict with wildlife in community-based conservation areas across northern Tanzania. *Oryx*, *50*(4), 702–712. https://doi.org/10.1017/S0030605315000393

Soto, B., Munthali, S. M., & Breen, C. (2001). Perceptions of the forestry and wildlife policy by the local communities living in the Maputo elephant reserve, Mozambique. *Biodiversity and Conservation*, *10*, 1723–1738. https://doi.org/10.1023/A:1012005620906

Ullah, I., & Kim, D. (2020). A model of collaborative governance for community-based trophy-hunting programs in developing countries. *Perspectives in Ecology and Conservation*, *18*(3), 145–160. https://doi.org/10.1016/j.pecon.2020.06.004

Virtanen, P. (2005). Community-based natural resource Management in Mozambique: A critical review of the concepts. *Sustainable Development*, *13*, 1–12. https://doi.org/10.1002/sd.240

Wertz-Kanounnikoff, S., Ribeiro, N., Guedes, B., & Giva, N. (2014). Community rights and participation in the face of new global interests in forests and lands: The case of Mozambique. In P. Katila, G. Galloway, W. de Jong, P. Pacheco, & G. Mery (Eds.), *Forests under pressure—Local responses to global issues* (Vol. 2, pp. 345–356). IUFRO World Series.

Wilson, S., Pearson, L. J., Kashima, Y., Lusher, D., & Pearson, L. (2013). Separating adaptive maintenance (resilience) and transformative capacity of social-ecological systems. *Ecology and Society*, *18*(1). https://doi.org/10.5751/ES-05100-180122

Wölfer, R., Faber, N. S., & Hewstone, M. (2015). Social network analysis in the science of groups: Cross-sectional and longitudinal applications for studying intra- and intergroup behavior. *Group Dynamics: Theory, Research, and Practice*, *19*(1), 45–61. https://doi.org/10.1037/gdn0000021

WWF. (2017). *Preventing paper parks: How to make the EU nature laws work*. (Report). WWF European Policy Office. www.edieuro.be

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