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The structure and pattern of global partnerships in the REDD+ mechanism

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ABSTRACT

Projects for reducing emissions from deforestation and forest degradation (REDD+) have been initiated in developing countries, featuring partnerships with multiple actors under the global forest and climate change regime. Even though partnerships between stakeholders are crucial for ensuring successful project deliveries, there is a lack of knowledge about sectoral partnerships within and between stakeholders in REDD+ projects. This study aims to measure the structures and patterns of REDD+ project partnerships using an original, multi-stage social network theory approach with global- and regional-level centralization analyses using three major regions (Asia, Africa and South America), and configurations using exponential random graph modeling (ERGM). Using data on 480 REDD+ projects implemented in 57 countries, results show concentrated polycentric networks across several dominant actors, including USA-, Brazil- and China-based organizations. Statistical network modeling indicates that, overall, partnerships are less likely to be created between different organization categories (across-type bridging), but tend more towards cooperation with the same types (within-type bridging). Research institutes, however, produce distinctly different patterns, forming across-type partnerships with highly technical capacities. Comparisons of stakeholders at different stages of the REDD+ mechanism help in understanding the complete picture of REDD+ architecture. This study contributes by offering insights for designing future partnerships within REDD+ projects and suggests ways to improve multi-level collaboration and cooperation.

1. Introduction

A range of stakeholders have interests in the reducing emissions from deforestation and forest degradation (REDD+) scheme and governance in other fields, such as development and environmental projects (Aryal et al., 2021; Bulkeley and Newell, 2010). When implementing REDD+, governance by various types of actors (public organizations, enterprises, non-governmental organizations, local communities and research institutes) creates project-specific networks (Corbera and Schroeder, 2011). Therefore, REDD+ is a vital forum for collaboration. Creating multi-level governance with different stakeholders is the essence of the REDD+ scheme (Cashore, 2002; Angelsen and McNeill, 2012). Partnerships between different actors can alleviate hurdles posed by a variety of factors during environmental and development initiatives. So, project implementors should find suitable partners for improving the delivery, accountability, efficiency and effectiveness of projects (Angelsen et al., 2018). Sometimes partnerships require high levels of communication, direct costs, and transaction costs for REDD+ activities, such as costs for information, implementation, enforcement, and monitoring (Köhl et al., 2020; Maraseni et al., 2014). Implementing REDD+ requires knowledge and resources that specific organizations cannot manage on their own (Gallemore and Munroe, 2013). To scale up such initiatives, the REDD+ Partnership, an international organization, was established at the Oslo Climate and Forest Conference in 2010 with the intention of facilitating funding, knowledge and technology transfer, mitigation actions and capacity building. Seventy-five countries have participated in the REDD+ Partnership. Partnership activities include capacity building and regional coordination meetings to enhance the transparency, efficiency and effectiveness of REDD+ activities.

Project proponents need to shape projects with an in-depth

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consideration of possible activities for partners, including state actors, NGOs, enterprises, indigenous communities, and all those who can influence project delivery (Overton and Storey, 2004). Specifically, REDD+ project implementors need to cooperate with the government entity that has the ultimate authority to operate projects, and with other stakeholders at subnational, regional and local levels, who have varying capacities and strategies to affect projects (Nepstad et al., 2013; McAllister and Taylor, 2015). According to Climate, Community and Biodiversity Standards (CCB Standards) validation or verification, proponents need to cooperate with partners that have the human resources or experience to implement projects (Verified Carbon Standard, 2019) and exchange ideas and knowledge (Vinke-de Kruijf, 2013). Likewise, partnerships are an inclusive vehicle for sustainable governance with combined capacity, such as knowledge, human, organizational, and financial resources (McAllister and Taylor, 2015). Where knowledge gaps are identified, proponents should determine how to make partnerships and strategies that fill those gaps (Verified Carbon Standard, 2019). Transboundary and multi-level governance in REDD+ projects works through partnerships but still encounters challenges, such as a lack of information and transparency in REDD+ project implementation (Angelsen et al., 2018). Moreover, discussion on how partnerships (as a means of information and resource-sharing) are formed within complex organizational arrangements remains underexplored (Lubell et al., 2014), although the importance of collaboration and coalition has frequently been discussed within adaptive governance (Holling et al., 2002; Lebel et al., 2006).

Analyses of the network structure of institutional collaborative behavior and complexity (Lubell, 2013), partnerships (McAllister et al., 2015) and project implementation (Nita et al., 2016) have been used widely to address environmental challenges around the world, including in conservation initiatives (Nita et al., 2016), water management (Lubell et al., 2014) and urban development (Chen et al., 2015). In terms of REDD+, the global REDD+ finance network was examined at the transnational level through a social network analysis (SNA) (Kim et al., 2019) with the REDD+ funding dataset for determining which institutions and countries were major contributors supporting REDD+. Gallemore and Munroe (2013) only explored the centralization of organizations in regard to financial and technical support for REDD+ projects. Moreover, their REDD+ project analysis informed jurisdictional approaches with the same data used in this study, i.e., the International Database on REDD+ projects and programs, linking Economic, Carbon, and Communities data (ID-RECCO)[1] (Wunder et al., 2020). Policy network analyses relating to REDD+ have been conducted extensively through interviews or surveys at the transnational level (Brockhaus and Di Gregorio, 2014; Fatorelli et al., 2015) and at the subnational level (Bushley, 2014; Brockhaus et al., 2014; Thuy et al., 2014; Rantala and Di Gregorio, 2014; Rantala, 2012; Babon et al., 2014). Previous research relating to REDD+ projects has focused primarily on finance or policy networks (Kim et al., 2019; Brockhaus and Di Gregorio, 2014; Fatorelli et al., 2015; Bushley, 2014; Brockhaus et al., 2014; Thuy et al., 2014; Rantala and Di Gregorio, 2014; Rantala, 2012; Babon et al., 2014). In this regard, we need a better understanding of how governance systems form and work in REDD+ projects and which organizations constitute the main actors implementing REDD+ projects.

Therefore, measuring the status, patterns and structures of multi-level partnerships is necessary for understanding best practices and implementation of REDD+ projects (Gallemore and Munroe, 2013; McAllister and Taylor, 2015). The purpose of this paper is to identify the structures, patterns and key players of partnership networks collaborating in REDD+ governance by exploring the linkages between stakeholders.

[1] ID-RECCO. International Database on REDD+ Projects and Programs, Linking Economic, Carbon and Communities Data. Version 3.0. Retrieved 20 March 2020, fromhttp://www.reddprojectsdatabase.org, 2020.

2. REDD+ history and architecture

2.1. REDD+ history

The first international debate about the role of forests in mitigating climate change was held within the context of the Kyoto Protocol at the third COP to the UNFCCC in 1997. Despite potential opportunities discussed, disputes resulted in a failure to negotiate, but eventually led to a compromise for afforestation/reforestation (A/R) projects in developing countries under the clean development mechanism (CDM) (Schulze et al., 2002). However, A/R projects have failed to attract donors due to "a lack of shared normative commitments" (Lövbrand, 2009) and high transaction costs for upfront-financial support since A/R projects typically require long-term and high-rate investment at the beginning, but a long time to secure benefits and revenues from carbon offsets after fulfilling required conditions (Haupt and Von Lüpke, 2007).

Before official discussions on REDD+ at the UNFCCC, the Coalition for Rainforest Nations (CfRN) was established to coordinate international initiatives in developing countries, involving 22 African countries, 10 Asian countries, six South American countries, 10 Caribbean and Central American countries, and five Oceanian countries (CfRN, 2020). CfRN was even backed by NGOs and scientists and made a critical voice in negotiations, especially during COP 11 to the UNFCCC (Pistorius, 2012). Papua New Guinea and Costa Rica brought Reducing Emissions from Deforestation (RED) to the agenda for the first time at COP 11 to the UNFCCC (UNFCCC, 2005). In 2007, during COP 13 in Bali, the Parties broadened the RED concept to Reducing Emissions from Deforestation and Forest Degradation (REDD). With an awareness of implicit challenges, such as transforming natural forests into plantations (Pistorius et al., 2011), the Parties at COP 13 included '+ (plus)' activities in negotiations. Under the definition of REDD+, its three categories depend on particular roles of forests: reducing emissions from deforestation and degradation (REDD), promoting afforestation, reforestation, and revegetation (ARR) under the Kyoto Protocol, and the integration of Improved Forest Management (IFM) under the UNFCCC for sustainable forest management (Simonet and Seyller, 2015).

2.2. REDD+ architecture

Participants in the REDD+ mechanism can be distinguished broadly as donors or recipients. Donors play an essential role in providing financial and technical support, but are still imperative for REDD+ implementation (Maraseni et al., 2020). They consist mainly of developed countries and non-state international institutions. Meanwhile, recipients are stakeholders at different levels (international, national, subnational, or local), including state- or non-state actors who receive aid from donors and oversee REDD+ implementation (Kim et al., 2019).

Fig. 1 explains the REDD+ process from funding and implementation to compensation. Following financial support, the first way to implement REDD+ is through sectoral policy. Through existing sectoral administrations, a variety of external resources directly assist regular budgets. National governments then set policies for following the REDD+ mechanism and developing independent national programs in connection with other governmental decision-making entities. These can be defined further at subnational, jurisdictional, and provincial government levels.

Another case is project-based funding, where payments are mainly channeled directly from donors to individual projects. This option includes specific proponent-partner structures where external entities in an international voluntary market can engage the private sector efficiently (Vatn and Angelsen, 2009). Since these options are interrelated, countries must consider diverse options that fit different national REDD+ strategy components. When it comes to national-level strategies, policies for co-benefits should be established, such as a Measurement, Reporting, and Verification (MRV) systems. A comprehensive process requires the establishment of an independent funding scheme (Vatn and

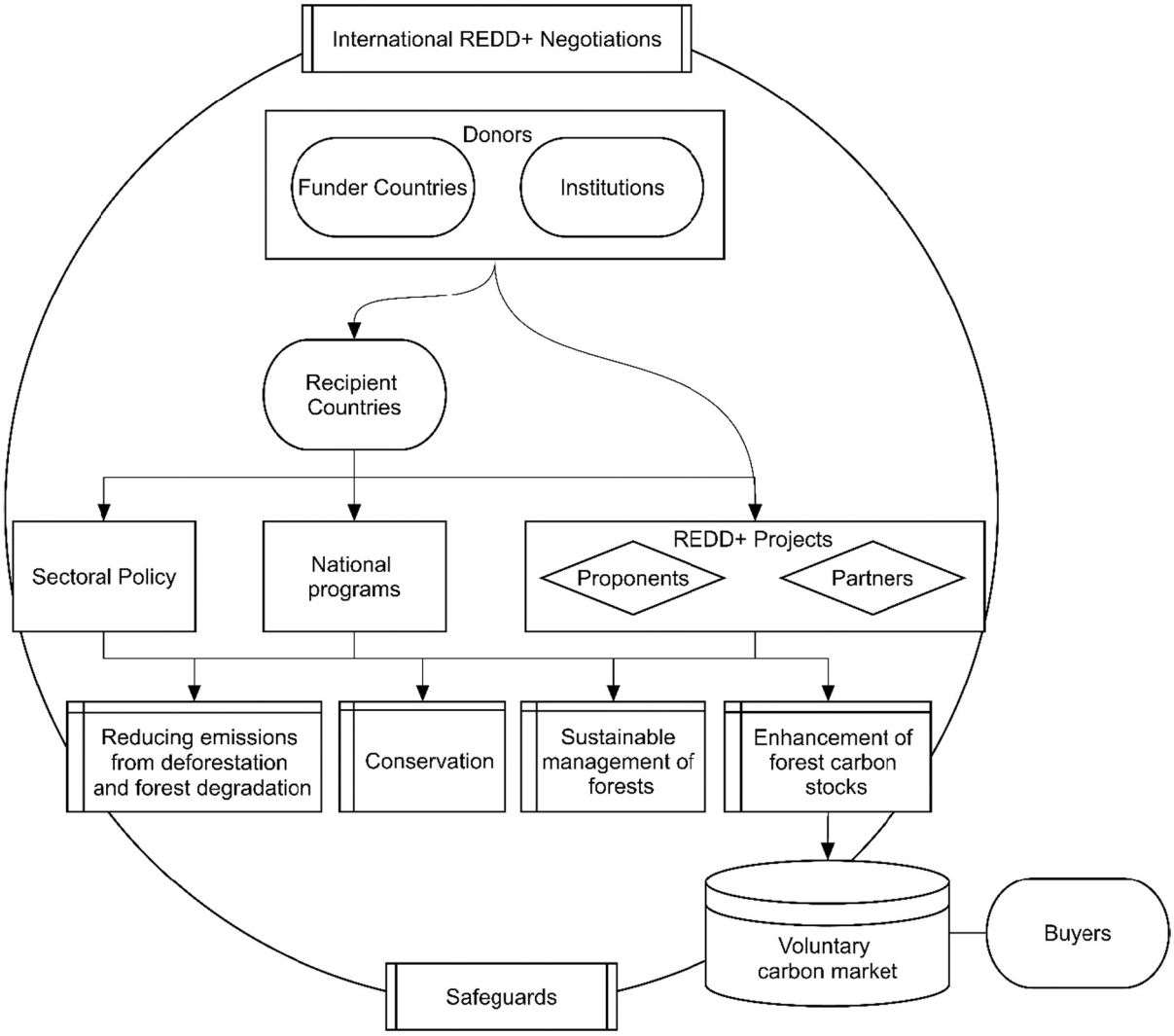


Fig. 1. REDD+ architecture.
Note: Modified from Simonet and Seyller (2015), Poffenberger et al. (2009), Vatn and Angelsen (2009), UNFCCC (2009), UNFCCC (2010).

Angelsen, 2009).

REDD+ projects have eligible activities in developing countries under the REDD+ umbrella: reducing emissions from deforestation and forest degradation; the role of conservation; sustainable management of forests; and enhancement of forest carbon stocks in developing countries (UNFCCC, 2009). Methodological guidance for eligible activities (UNFCCC, 2009) announces more substantive and specific requirements for REDD+: specific policy approaches and incentives (the Subsidiary Body for Scientific and Technological Advice); cooperative efforts with diverse stakeholders with full engagement of indigenous peoples and local communities; sustainable forest management; co-benefits such as biodiversity; lessons learned from ongoing activities; efforts in capacity building; methodologies; and monitoring. Following Decision 1/CP. 16 at UNFCCC COP 16 (UNFCCC, 2010), environmental and social safeguards should be secured throughout REDD+ phases to eliminate or minimize detrimental impacts on the environment or society from REDD+ implementation (UNFCCC, 2012).

The voluntary carbon market has demonstrated substantial social and environmental credits from projects. The most well-established and well-known standards are the Climate, Community and Biodiversity Project Design Standards (CCB Standards), the UNFCCC CDM and the Voluntary Carbon Standard (VCS), and the Plan Vivo System (Simonet et al., 2015; Estrada, 2011). Based on these standards, net carbon credits are estimated from the project baseline, discounting leakage and emissions during project implementation (Estrada, 2011). These carbon offset credential systems have broadened the voluntary carbon market, increased buyers, and contributed to achieving the goals of REDD+ projects (Vatn and Angelsen, 2009).

3. Research design and methods

3.1. Research design

The leading theory of this study is social network analysis (SNA), which is a well-known tool to explore the structure, centrality, and distribution of various networks and partnerships (Borgatti et al., 2018). There are two ways to analyze social networks: 1-mode and 2-mode. In a 1-mode network, the dataset consists of a single group of entities, while the dataset in a 2-mode network is separated by two sets of entities (e.g., projects and partners) (Borgatti and Everett, 1997). This study uses two sets of nodes to highlight partnerships formed in REDD+ projects. The project represents the first set of nodes as a coalition venue for partners, and the other set as project partners.

Quantifying network metrics is the key to answering which countries and which types of organizations are the most dominant and efficient to control communication at the global and regional level in the REDD+ partnership network (Bonacich, 2007). As a statistical network method, exponential random graph modeling (ERGM) shows the pattern to

create partnerships between different organizational categories. In this way, the results help to understand and map comprehensive pictures of the large-scale complex networks of REDD+ projects (Boccaletti et al., 2014).

In this regard, we address the following research questions by using social network theory: Research Question 1: Which countries and organizations/Which type of organizations are dominant and influential in partnerships at the global level and regional level when REDD+ projects are implemented? and Research Question 2: Which types of partnerships arise and what patterns do partnerships construct in REDD+ projects based on the characteristics of the types of organizations?

This study has three types of analyses: centrality analyses at the global and regional levels to answer Research Question 1, and statistical network modeling (ERGM) analyses (configurations) to answer Research Question 2 (Fig. 2).

3.2. Data

The dataset used in the study contains 523 REDD+ projects and programs in 57 countries. We obtained 467 REDD+ projects from the ID-RECCO database (ID-RECCO, 2020), the International Database on REDD+ projects and programs, and ID-RECCO data. We then added 56 more projects from the same source, where ID-RECCO collected REDD+ project data. Key sources of the database are project documents designed for certification of the voluntary carbon market to sell carbon offsets, including VCS, CDM, Plan Vivo, and the Climate, Community and Biodiversity Alliance (CCBA) (Simonet et al., 2015). ID-RECCO is a joint effort in the collaboration, with data collected by the Center for International Forestry Research (CIFOR), Climate Economics Chair (Paris-Dauphine University, France), Centre de coopération internationale en recherche agronomique pour le développement (CIRAD, Montpellier, France), and the University of Michigan's International Forestry Resources and Institutes (IFRI) until 2018, and subsequently by CIFOR, the Earth Innovation Institute and the Governors' Climate and Forests Task Force (Simonet et al., 2018). Organizations involved in the ID-RECCO project have collected on-the-ground documents about REDD+ projects from different sources (certification and project development documents), coded with 110 variables per project. Given that there was no official database of REDD+ projects until 2015 (Simonet and Seyller, 2015), Simonet et al. (2018) created a central database that tracks REDD+ projects worldwide (Simonet et al., 2018). We excluded 43 terminated, abandoned or planned projects, so 480 projects were finally included.

The network dataset for social network analysis consisted of linked projects and organizations (Wasserman and Faust, 1994). In the coding process, the main data extracted from each project was the project ID, organization name, organization type, the country and continent of origin for each organization, project duration and project title (Appendix 1). We then double-checked and standardized organization names to avoid duplication errors. The organizations were classified in five categories according to legal status: public organizations, NGOs, research institutes, enterprises and local communities. For analyses, the initial dataset was rearranged as a bipartite network (2-mode) with one node being REDD+ projects, and the other being proponents and partners participating in the same REDD+ projects. According to the number of each node, an n-by-m matrix was created without weight. A link between a project and organization in the same REDD+ project was assigned a value of 1, while a 0 was assigned if there was no link (Wang et al., 2009). For bipartite network analysis, most calculations and visualizations of metrics were conducted using NetMiner software 4.0 (Cyram, 2013), while MPNet was used for statistical analysis (ERGM) (Wang et al., 2014).

3.3. Centrality

In response to Research Question 1, we built Dataset 2 and Dataset 3 to examine the centrality of each organization and country in the REDD+ project network at the global level with Dataset 2 and regional level with Dataset 3. For region-specific network analysis, the original dataset was filtered by continent where most REDD+ projects have been

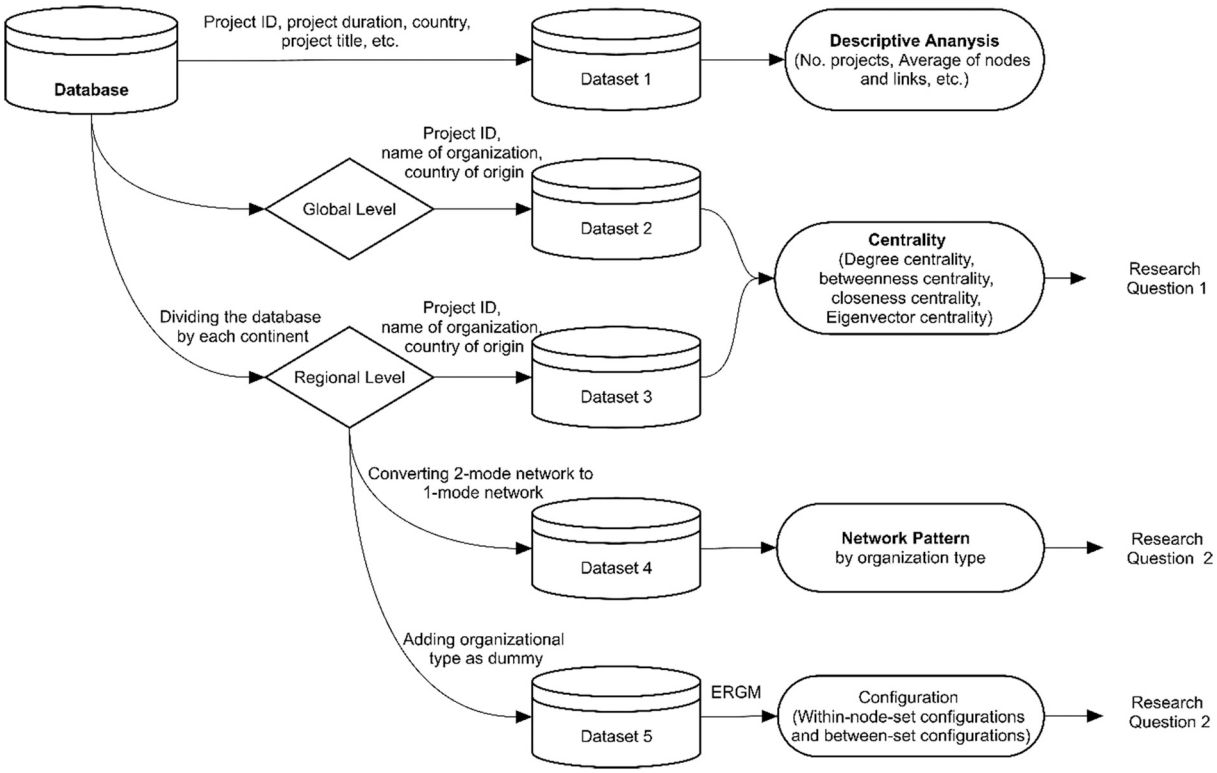


Fig. 2. Conceptual framework.

implemented: Africa, South America and Asia. Both Dataset 2 and Dataset 3 used project ID, the name of the organization, and the location of its headquarters (country) to design two sets of metrics: (1) project ID and organization name; and (2) project ID and location of headquarters. We then calculated the degree centrality, betweenness centrality, closeness centrality and Eigenvector centrality of each node (Bonacich, 2007; Opsahl et al., 2010). The interpretation of centrality measures at both global and regional levels would be similar, but region-specific properties were measured only at the regional level.

Degree centrality refers to how many ties nodes connect to, which shows the number of direct connections to an individual project, organization and country at the global level (Opsahl et al., 2010). Betweenness centrality represents how many times a node appears in the shortest path between nodes. The higher the betweenness centrality a country has, the more able it is to control the flow in the REDD+ partnership network since it funnels the interaction (information, experience, know-how, etc.) between countries (Opsahl et al., 2010; Borgatti et al., 2018). Closeness centrality shows the total inversive distance of the paths to all other nodes from a node in the network settings. A country with a high closeness centrality has greater power to enable the flow of information as it is close to many other nodes (Borgatti and Everett, 1997; Borgatti et al., 2018). Eigenvector centrality is the sum of both direct and indirect ties of every length representing the influence of its neighbors (Bonacich, 2007). The measure also describes the impact of a node, as the higher the Eigenvector centrality, the more likely a node is to connect to other nodes with high scores (Borgatti and Everett, 1997; Borgatti et al., 2018).

3.4. Configuration

We used ERGM (p* models) to calculate the probability of REDD+ partnership network structure and understand which types of partnership arise within the continents (Research Question 2) (Wang et al., 2009; Wang et al., 2013). We made Dataset 4 with dummy values for each organization type to determine structural configurations by category: public organization, NGO, research institute, enterprise and local community. If a category attribute was present, we assigned a value of 1. Otherwise, it was coded as 0. We analyzed the matrix of Dataset 4 using MPNet (Wang et al., 2014).

Based on configuration statistics, the selected graphs had ERGM probability. The generalized ERGM form was as follows (Wang, 2013):

$$P_\theta(X = x) = \frac{1}{k(\theta)} exp \sum_q \theta_q z_q(\mathrm{x})$$

Where:

θ_q represents the vector of the parameter (θ) for the network configuration q;

z_q(x) denotes the vector of network statistic corresponding to network configuration q, which shows the relative importance of the individual network configuration q;

$k(\theta)$ is a normalizing constant.

The bipartite network displays the relationship between projects and actors, and ERGM models with bipartite networks estimate a variety of structural configurations, such as star configurations, alternating stars and edge cycles. In addition, between-set configurations with binary attributes were observed, including activity, cycles, across-type bridging, and within-type bridging (Wang et al., 2009; Wang et al., 2013; Wang, 2013). To find the adequate fit for the model, we first ran the model with the selected network configurations using MPNet. If the t-ratios in estimations were smaller than 4 for all values, we increased the multiplication factor and reran the model until t-ratios had a small enough value (Appendix 2) (Koskinen and Snijders, 2013). We then analyzed a Goodness-of-Fit (GOF) for the converged models by comparing the observed model to estimates from the converged model with 100 million simulations (Wang et al., 2009), which showed and assessed how well the estimated statistics fitted. Only when t-ratios in GOF in absolute values were smaller than 2 would we present the model statistics (Appendix 2) (Wang et al., 2014).

4. Results

4.1. Descriptive analysis

Studies explored the location of REDD+ projects in 2010 (Cerbu et al., 2011) and 2014 (Simonet et al., 2015) as a critical variable for global analysis. Our results provide up-to-date information on REDD+ projects collected until June 2020 (Fig. 3). The results show that a few countries, such as Brazil (59 projects), Columbia (43), China (35), Indonesia (31) and Peru (30) have mostly attracted sponsors of REDD+ projects. At the regional level, 43% of all projects have been implemented in South America, 30% in Africa and 25% in Asia.

Fig. 4 shows that REDD+ projects and international agreements on climate change have a positive correlation. More specifically, ARR projects have been implemented since the first phase (CDM mechanism) began under the Kyoto Protocol adopted at COP 3 in 1997. Even though ARR projects initially fell under the CDM mechanism, they later became part of REDD+ as certified for voluntary carbon markets. A downtrend in REDD+ implementation was observed after 2012 in line with uncertainty and financing difficulties, especially in European markets (Simonet et al., 2015). Even though some countries, such as China, have started self-supported REDD+ projects with regional partners, the number of newly established REDD+ projects has decreased in recent years.

In the database, 1744 project stakeholders have participated in REDD+ projects (Fig. 5). The largest group is enterprises (30%) looking for capital-generating carbon markets, followed by NGOs (28%) for conservation, and public organizations (25%) (Simonet et al., 2015). Research institutes (10%) and local communities (3%) have relatively smaller shares.

4.2. Centrality

With Dataset 2, a country-by-country analysis and stakeholder analysis were performed at the global level. In the country-by-country analysis (Fig. 6A), one set of the network was project ID, and the other set was the location of each organization's headquarters. In the analysis of individual stakeholders (Fig. 6B), the network comprised project ID (one mode) and stakeholders (the other mode).

The country-by-country network (Fig. 6A) shows that nodes are grouped by continent, and nodes of developing countries are located at the heart of the network, forming partnerships with stakeholders from various countries. Specifically, the USA is the most powerful country as a supporter of developing countries and the most influential in the whole network. The USA has the highest centrality values (degree centrality: 0.344, betweenness centrality: 0.589, closeness centrality: 0.472, and Eigenvector centrality: 0.393) (Table 1). Among developing country hosts, Brazil, China, Peru, Colombia and Indonesia have successfully attracted many REDD+ projects. Brazilian partners have a higher betweenness index (0.131) than others, though its closeness centrality is similar to other host countries (Brazil: 0.335, China: 0.301, Peru: 0.320, Colombia: 0.324 and Indonesia: 0.309) (Table 1).

In the network of individual stakeholders (Fig. 6B), actors in the network make groups by region like the country-by-country analysis (Fig. 6A). North American and European partners are usually in the center of the network, but some with region-specific partnerships are in the relevant region. Seven of the top-10 stakeholders in terms of betweenness centrality are NGOs. Nine of the top-10 actors have their headquarters in developed countries, particularly the USA (six organizations) (Table 2). Organizations such as Conservation International (CI), the World Wide Fund for Nature (WWF), and Wildlife Conservation Society (WCS), have been central as project proponents. Institutions

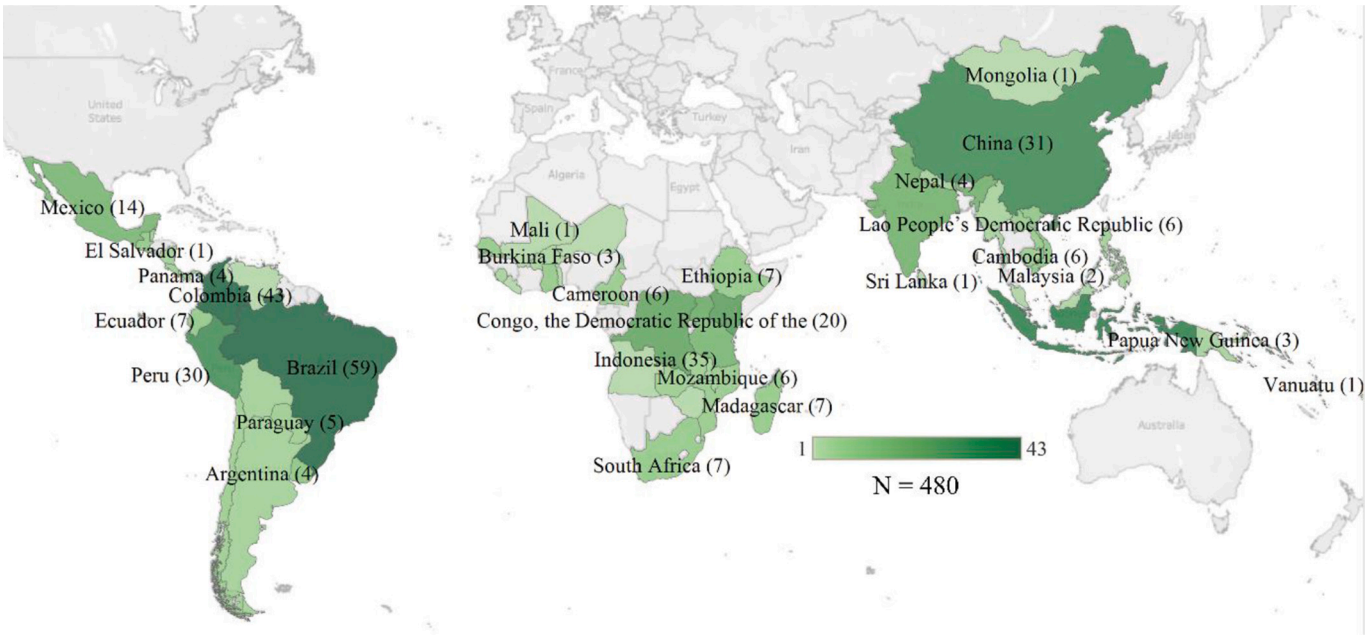


Fig. 3. Geographic distribution of global REDD+ projects in developing countries.
Note: The darker the color, the higher the number of REDD+ projects.

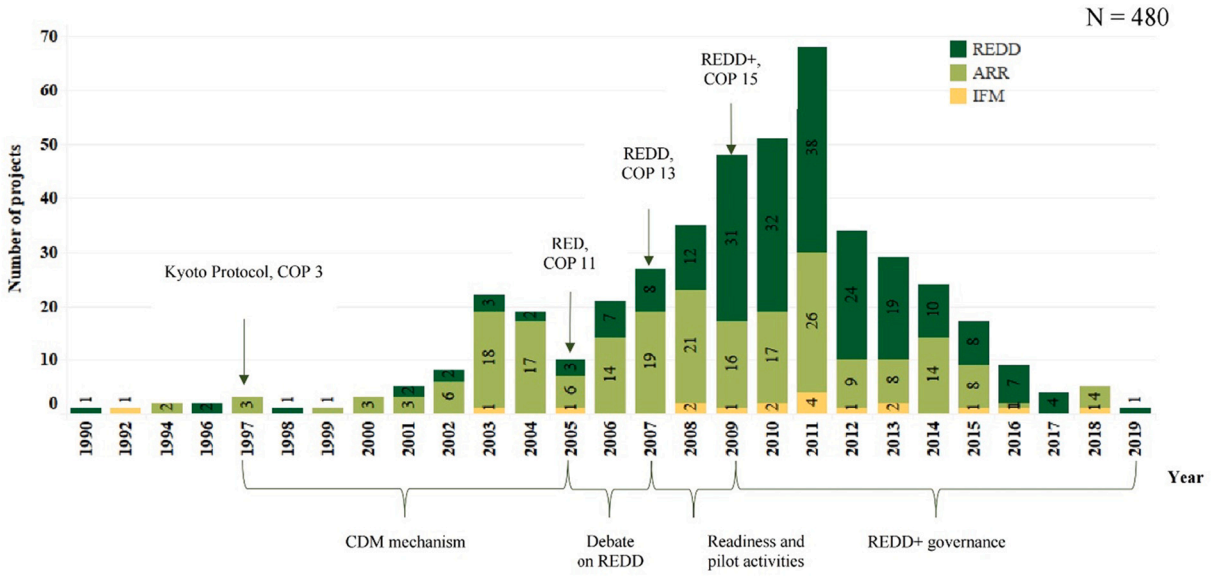


Fig. 4. Numbers of newly initiated REDD+ projects in developing countries.
Note:
Year = year of project commencement.
COP = Conference of Parties; ARR = Afforestation, Reforestation and Revegetation; IFM = Improved Forest Management.

such as the Nature Conservancy and the United States Agency for International Development (USAID) play essential roles as partners.

With Dataset 3, a region-specific network analysis was conducted by continent: Africa, South America and Asia. A regional-level analysis also included a country-by-country analysis (Fig. 7A, B and C) and stakeholder analysis (Fig. 7D, E and F) like the previous global-level analysis (Fig. 6A and B). The country-by-country analysis used project ID as one set and the location of each organization's headquarters as the other set. In the stakeholder analysis (Fig. 7D, E and F), the network consists of project ID (one mode) and stakeholders (the other mode) connected to the project by region. In Africa (Fig. 7A and D), the REDD+ project network is centered on the USA, United Kingdom and Switzerland as supporting countries. WCS, Care International, WWF and UNDP are the most active organizations with high centrality values in Africa. Among host countries, Uganda and Kenya have attracted many REDD+ projects.

The Asia network (Fig. 7B and E) shows supporting countries such as the USA, Switzerland and Germany playing significant roles, with key players being World Education Inc., GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit), the Nature Conservancy (TNC), Flora and Fauna International (FFI) and WWF. Most REDD+ projects have been implemented in China and Indonesia. The remarkable feature is that China is located outside rather than at the center of the network, despite its high centrality index (Fig. 7B). This indicates REDD+ projects conducted in China not usually involving transnational partnerships, but

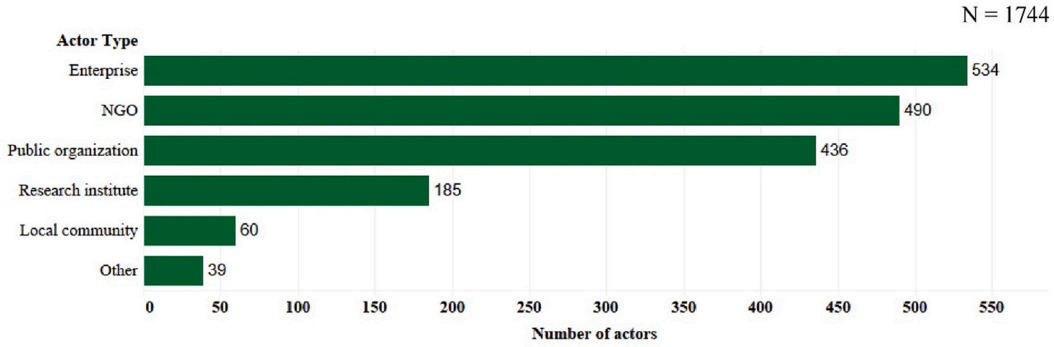
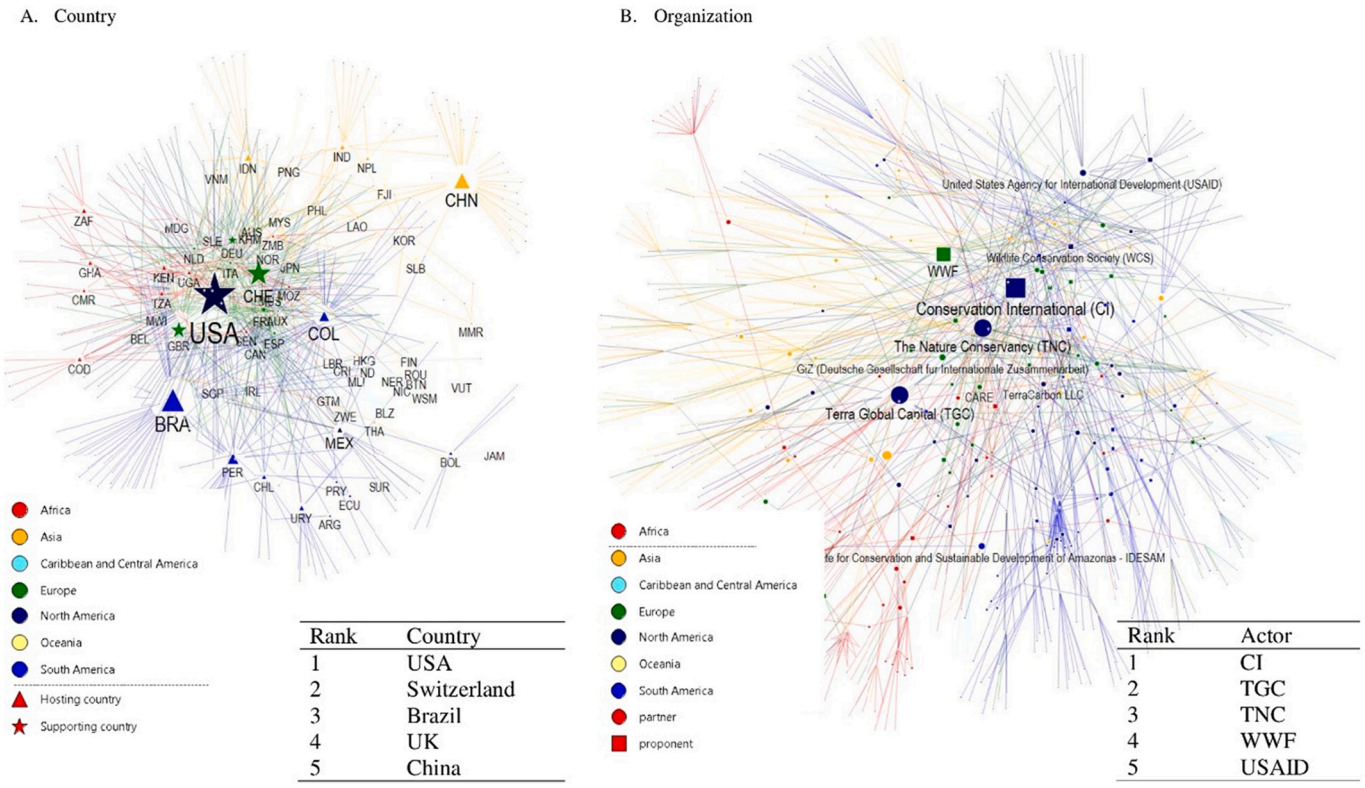


Fig. 5. Numbers of actors in REDD+ project partnerships by type.



Rank	Country
1	USA
2	Switzerland
3	Brazil
4	UK
5	China

Rank	Actor
1	CI
2	TGC
3	TNC
4	WWF
5	USAID

Fig. 6. Global networks of REDD+ project partnerships by country and by organization.
Note:
Network A by country (triangle = hosting country and star = supporting country); and Network B by organization (circle = partner and square = proponent).
Colors of nodes and links were given to each continent for better readability (Africa - red; Asia - orange; Caribbean and Central America - light blue; Europe - green; North America - purple; Oceania - yellow; and South America - blue).
The sizes of nodes were determined by measure of betweenness centrality.
CI = Conservation International; TNC = The Nature Conservancy; WWF = World Wide Fund for Nature; USAID = United States Agency for International Development. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

partnerships with national organizations. Only 13% of the 31 projects implemented in China have partners from other countries, while 87% of projects work with national stakeholders or organizations located in China. In contrast, 89% of the 35 projects implemented in Indonesia are based on transnational partnerships (Fig. 7B).

In the South America network (Fig. 7C), vital supporting countries (USA, Switzerland and the United Kingdom) are the same as for Africa. However, the key partners, CI, TNC and Terra Carbon LLC, are different to other regions (Fig. 7F). Three countries, Brazil, Peru and Colombia, are major hosting countries with high centrality values (Fig. 7C).

Overall, USA stakeholders dominate networks in all regions, but dominant organizations differ from region to region, with the Wildlife Conservation Society (WCS) centered in Africa, World Education Inc. in Asia, and Conservation International (CI) in South America (Fig. 7D, E and F). In other words, particular institutions are not central to all continents, as each region has different players and patterns.

4.3. Configuration

Using ERGM, we determined whether configurations (e.g., within-type and across-type partnerships) appear more or less frequently than could be formed statistically in the REDD+ partnership network (Wang et al., 2009; Wang et al., 2013; McAllister et al., 2015). By using t-statistics, this model provides predicted configurations as a base for

Table 1
Centrality of countries in the global partnership network.

Country type	Rank	Country	Degree centrality	Betweenness centrality	Closeness centrality	Eigenvector centrality
Supporting	1	USA	0.344	0.589	0.472	0.393
	2	Switzerland	0.106	0.153	0.389	0.010
	3	UK	0.091	0.104	0.362	0.008
	4	Germany	0.068	0.063	0.342	0.004
	5	France	0.056	0.049	0.344	0.012
	6	Spain	0.046	0.033	0.344	0.002
	7	Italy	0.039	0.022	0.328	0.003
	8	Canada	0.037	0.021	0.335	0.004
	9	Netherlands	0.025	0.019	0.313	0.001
	10	Japan	0.023	0.013	0.305	0.002
Hosting	1	Brazil	0.120	0.130	0.335	0.022
	2	China	0.066	0.091	0.301	0.003
	3	Peru	0.058	0.067	0.320	0.003
	4	Colombia	0.077	0.061	0.324	0.919
	5	Indonesia	0.056	0.037	0.309	0.005
	6	Mexico	0.035	0.031	0.310	0.002
	7	India	0.033	0.030	0.298	0.002
	8	Uruguay	0.023	0.028	0.244	0.000
	9	Kenya	0.041	0.022	0.347	0.017
	10	South Africa	0.017	0.021	0.243	0.000

Note: The order of variables in the output table is based on betweenness centrality value.

Table 2
Centrality of countries in the global partnership network.

Rank	Name	Country	Type	Degree centrality	Betweenness centrality	Closeness centrality	Eigenvector centrality
1	Conservation International (CI)	USA	NGO	0.029	0.110	0.341	0.000
2	Terra Global Capital (TGC)	USA	NGO	0.033	0.097	0.309	0.306
3	The Nature Conservancy (TNC)	USA	NGO	0.037	0.097	0.303	0.000
4	WWF	Switzerland	NGO	0.041	0.079	0.312	0.000
5	United States Agency for International Development (USAID)	USA	Public organization	0.029	0.037	0.290	0.022
6	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit)	Germany	Public organization	0.017	0.037	0.294	0.000
7	Institute for Conservation and Sustainable Development of Amazonas - IDESAM	Brazil	NGO	0.004	0.034	0.228	0.000
8	Wildlife Conservation Society (WCS)	USA	NGO	0.027	0.034	0.283	0.000
9	TerraCarbon LLC	USA	Enterprise	0.012	0.030	0.268	0.000
10	CARE	Switzerland	NGO	0.010	0.030	0.286	0.005

comparing observations. In other words, through the statistical process, ERGM models help explain network processes and draw rigorous and unbiased interpretations about the abundance of configurations, without the necessity to compare multiple networks.

Our ERGM models had bipartite configurations across regions and organizational categories based on Dataset 4 (Appendix 1). The two main configurations were activity and bridging configurations. In all regions, fewer activity configurations were observed than expected (Table 3). Projects implemented in Africa tended to have fewer bridging structures than expected. Thus, organizations have a lower propensity than expected to attract many projects. Activity estimates for each organization type were not statistically significant, but only research institutes in South America had fewer activities. The tendency for organizations to have within-type bridging and across-type bridging differs between organization category and region. Overall, configurations for within-type and across-type bridging show opposing aspects. Public organizations in Africa, for example, have a higher tendency towards across-type bridging, but are less likely to form partnerships with the same organization type. Conversely, in Asia there are fewer partnerships involving public organizations with other organization types, while there is more within-type bridging (Table 3). Details of configurations will be explored in the discussion below.

5. Discussion

This research examined global networks (Fig. 6) and regional networks (Fig. 7) of REDD+ projects based on partnerships between five organization types. REDD+ partnerships have successfully improved REDD+ actions against climate change as informal fora for collaboration and communication to enhance transparency, shared knowledge, understanding, trust, and capacities on REDD+ issues (La Viña and Lee, 2015; Maraseni et al., 2020). REDD+ project cooperation has different structures and patterns between regions and organization types, which determine the overall shape of REDD+ project partnerships. As partnerships offer leverage for diverse stakeholders to govern (McAllister and Taylor, 2015), these cooperation patterns allow us to understand how stakeholders interact with each other for successful REDD+ project implementation. Here we discuss results focusing on centralization and coordination/collaboration for answering the research questions posed in the research model section.

5.1. Centralization (key countries and organizations)

During the development of the REDD+ mechanism (Fig. 1), efforts were made to determine who has the greatest power and who leads the REDD+ system. However, centralization patterns of the whole REDD+ architecture remain ambiguous (Gallemore and Munroe, 2013). Results indicate that numerous stakeholders from both developing and developed countries have participated in REDD+ projects with different interests (e.g., preferred locality, country, regions, or project outputs), but a few central actors have contributed enormously to REDD+. Central organizations in advantageous positions in networks have influence and

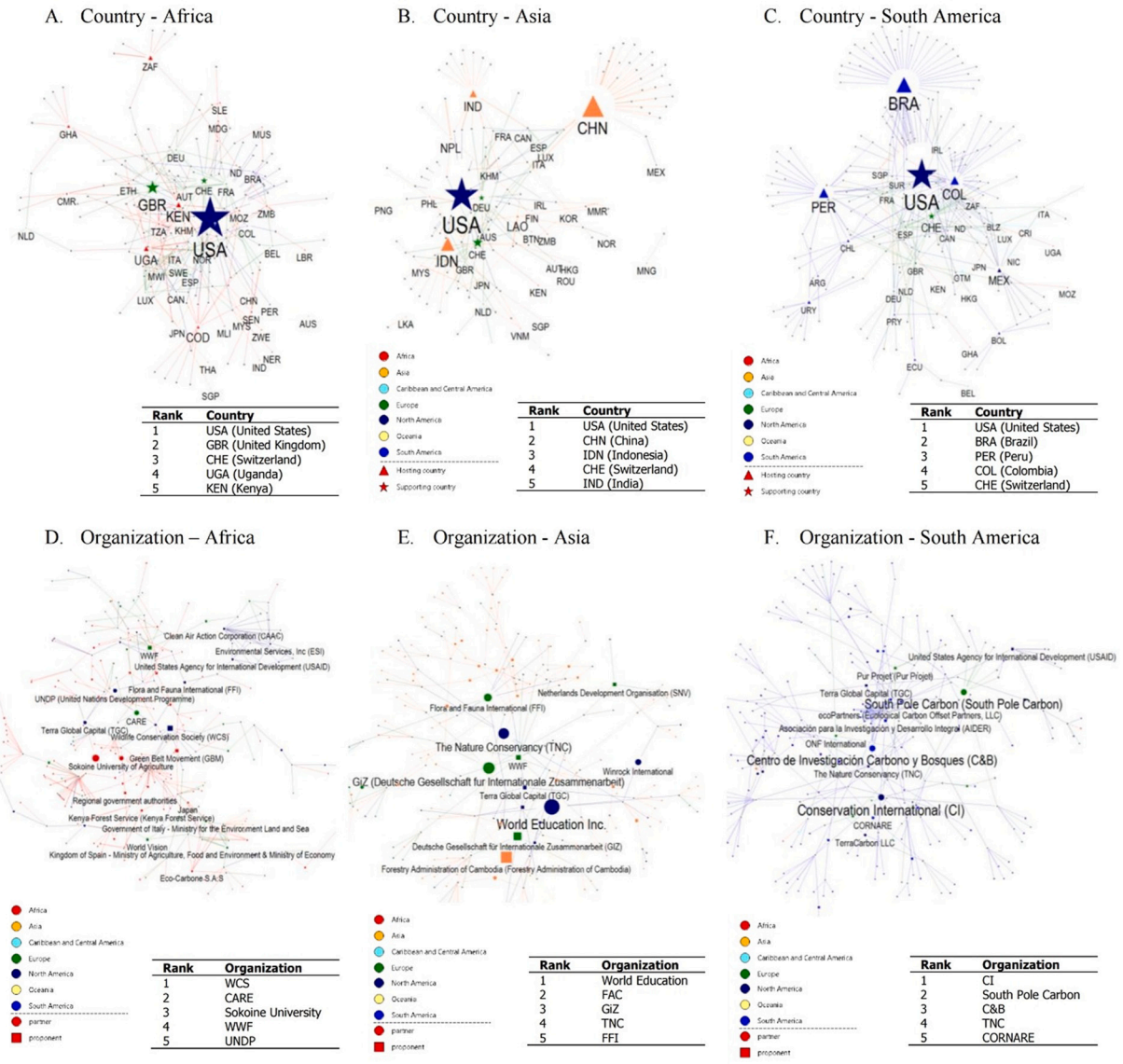


Fig. 7. Regional REDD+ project partnership networks by continent.
Note:
A ~ C: regional networks by country (triangle = hosting country and star = supporting country); and D ~ F: regional networks by organization (circle = partner and square = proponent).
Colors of nodes and links were given to each continent for better readability (Africa - red; Asia - orange; Caribbean and Central America - light blue; Europe - green; North America - purple; Oceania - yellow; South America - blue).
The sizes of nodes were determined by measure of betweenness centrality.
CI = Conservation International; TNC = The Nature Conservancy; WWF = World Wide Fund for Nature; WCS = Wildlife Conservation Society; UNDP = United Nations Development Programme; GIZ = Deutsche Gesellschaft für Internationale Zusammenarbeit; FFI = Flora and Fauna International; C&B = Centro de Investigación Carbono y Bosques; FAC = Forestry Administration of Cambodia.

power as leverage or brokerage for resources and knowledge (Vinke-de Kruijf, 2013; McAllister and Taylor, 2015). Project developers and partners who display distinct interests choose their target regions and countries according to the nature of their organization (Simonet et al., 2015). For example, the International Centre for Integrated Mountain Development (ICIMOD) supports projects targeting the Himalayan mountains in Southern Asian countries (Rana, 2003). The visualized results (Figs. 6 and 7) also show where power is centralized in particular countries and organizations, though influential actors vary from region to region. By using REDD+ projects and networks, centralization and partnership patterns in REDD+ projects are discussed and highlighted compared to finance networks from previous research (Kim et al., 2019).

Key players at the project level are mostly USA-based organizations across the world, despite Norway and Japan providing the most financing (Table 4). Table 1 shows that USA partners with high centrality are connected to influential organizations from other countries (Eigenvector centrality) (Bonacich, 2007) and play a significant role in controlling (betweenness centrality) and enabling (closeness centrality) interactions, including partnerships, knowledge sharing and communication within REDD+ project networks (Borgatti and Everett, 1997; Opsahl et al., 2010; Borgatti et al., 2018). Most of the organizations located in the USA are NGOs (36%) and private actors (34%). Notably, USA-based NGOs and companies have been supporting REDD+ projects and have sponsored REDD+ pilot project models, including avoided deforestation and United States Initiative on Joint Implementation (USIJI) projects under CDM (Lile et al., 1998). However, the USA

Table 3
Exponential Random Graph Models (ERGMs) for REDD+ project partnerships.

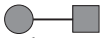
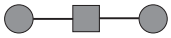
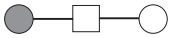
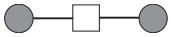
Configurations	Category	Africa		Asia		South America	
		More/Less likely	Parameter (SE)	More/Less likely	Parameter (SE)	More/Less likely	Parameter (SE)
Activity							
	actor-project	Less	−5.16 (0.33)*	Less	−4.44 (0.27)*	Less	−4.58 (0.22)*
Bridging							
	actor-project-actor	More	0.09 (0.00)*	–	−0.15 (0.08)	Less	−0.18 (0.09)*
Dummy variables							
Activity							
	Public organization	–	0.26 (0.27)	–	0.14 (0.31)	–	−0.29 (0.21)
	Enterprise	–	0.60 (0.50)	–	0.29 (0.28)	–	−0.15 (0.24)
	NGO	–	0.65 (0.55)	–	0.16 (0.30)	–	−0.20 (0.24)
	Research institute	–	0.33 (0.57)	–	−0.69 (0.49)	Less	−0.94 (0.38)*
	Local community	–	−0.23 (0.32)	–	1.17 (0.66)	–	−0.42 (0.74)
Across-type bridging							
	Public organization	More	0.06 (0.02)*	Less	−0.13 (0.06)*	–	–
	Enterprise	Less	−0.02 (0.01)*	Less	−0.12 (0.06)*	Less	−0.10 (0.05)*
	NGO	Less	−0.05 (0.02)*		0.01 (0.07)	–	−0.08 (0.06)
	Research institute	–	0.00 (0.02)	More	0.20 (0.09)*	More	0.23 (0.10)*
	Local community	Less	−0.02 (0.01)*		0.16 (0.15)	–	0.09 (0.16)
Within-type bridging							
	Public organization	Less	−0.06 (0.02)*	More	0.23 (0.10)*	–	–
	Enterprise	–	−0.10 (0.20)	More	0.27 (0.10)*	More	0.18 (0.09)*
	NGO	–	−0.18 (0.41)	–	0.10 (0.17)	–	0.19 (0.14)
	Research institute	–	0.08 (0.17)	–	–	–	−0.43 (0.54)
	Local community	More	0.71 (0.01)*	–	−0.17 (1.32)	–	–

Table 4
Key players in finance and project networks in the REDD mechanism.

Rank	Recipient Countries		Donor Countries		Organization	
	Amount of finance	Number of Partnerships	Amount of finance	Number of Partnerships	Amount of finance	Number of Partnerships
1	Brazil	Brazil	Norway	USA	GEF	WWF
2	Indonesia	Colombia	Japan	Switzerland	FIP	TNC
3	India	China	Germany	UK	World bank	TGC
4	Mexico	Peru	UK	Germany	EC	CAAC
5	China	Indonesia	USA	France	FCPF	CI
6	DRC	Kenya	France	Spain	UN-REDD	USAID
7	Ghana	Mexico	Australia	Italy	WCS	WCS
8	Guyana	Uganda	Finland	Canada	IUCN	FFI
9	Peru	India	Canada	Luxemburg	WWF	South Pole Carbon
10	Nepal	DCR	Sweden	Netherlands	CI	Eco-Carbone SAS

Note:
1. White blocks represent the results from this research and grey blocks present results from the finance network analysis of Kim et al. (2019).
2. CI (Conservation International), CCAC (Clean Air Action Corporation), C&B (Centro de Investigación Carbono y Bosques), EC (European Commission), FCPF (Forest Carbon Partnership Facility), FIP (Forest Investment Program), FFI (Flora and Fauna International), GEF (Global Environment Facility), GiZ (Deutsche Gesellschaft für Internationale Zusammenarbeit), TNC (The Nature Conservancy), UNDP (United Nations Development Programme), WWF (World Wide Fund for Nature) and WCS (Wildlife Conservation Society).

government gave no funds to USIJI projects (Lile et al., 1998; Dixon, 2012). Small and medium enterprises in particular have actively provided logistical, financial and technical support to develop forest-related projects (Dixon, 1998). With accumulated experience and well-equipped location, USA-based organizations were likely to grow "network power" (Grewal, 2008). Therefore, USA-based organizations have a comparative advantage and attractiveness as partners in building connections with developing countries (Gallemore and Munroe, 2013). USA-based actors have actively formed partnerships in REDD+ project networks (Tables 1, 2 and 4).

Among developing countries, Brazil received not only the majority of financial support, but also the greatest number of projects and partnerships (Table 4). It seems to have a high capacity for the requirements to proceed with REDD+, including its large area of tropical forests. Another significant reason for Brazil being centered among developing countries in the network is its Amazon Fund established by the Brazilian government. The Fund's main objective is to capture and attract many donors for REDD+ projects in Brazil (Cenamo et al., 2009). The Amazon Fund has led to voluntary donations from diverse stakeholders and the fund also has specific guidelines for encouraging contributions and engagement from a diverse range of stakeholders for REDD+ projects under the fund (Guideline A3 – Diversity of Stakeholders and Shared Governance) (Amazon Fund, 2013). In Asia, China and Indonesia are two key countries implementing REDD+ projects. In previous studies (Cerbu et al., 2011; Simonet et al., 2015), China did not have many REDD+ projects. For example, Cerbu et al. (2011) categorized China as a country with less than 15 projects. However, Fig. 3 shows China ranking third in REDD+ project implementation and certification. There should be a link between the number of REDD+ projects and the characteristics of countries, such as large areas of humid forests as a possible generator of carbon offsets (Simonet et al., 2015). A remarkable feature is China being located outside rather than at the center of the network, in spite of

its high centrality index (Fig. 7B). This indicates REDD+ projects conducted in China not usually involving transnational partnerships, but partnerships with national organizations. Only 13% of the 31 projects implemented in China have partners from other countries, while 87% of projects work with national stakeholders or organizations located in China. In contrast, 89% of the 35 projects implemented in Indonesia are based on transnational partnerships (Fig. 7B).

In terms of organizations, seven of the top-10 most influential brokers (ordered by betweenness centrality) are NGOs (Table 4), despite the total numbers of actors by organization type being similar: public organizations (283), enterprises (296) and NGOs (279) (see Appendix 3). NGOs had already been conducting conservation development projects and later customized them for REDD+ projects using classic methods, including payment for ecosystem services (PES) and plantation establishment (Simonet et al., 2015). Since the outset of REDD+, NGOs have expanded their influence greatly and engaged in project implementation and information flow (Gallemore and Munroe, 2013). Conservation International, the Nature Conservancy and Care International collaborated to establish the Climate, Community and Biodiversity Alliance (CCBA) in 2004 in order to secure benefits for local livelihoods and biodiversity (CCBA, 2008). These NGOs, as partners, have been actively involved not only in the constitutionalization and development of REDD+ (Everett and Borgatti, 2013), but also in the implementation of REDD+ projects, and have the most significant power over information flow (Table 2). It indicates that NGOs take advantage of designing REDD+ projects by fitting existing projects to REDD+ standards without fundamental changes. Similarly, NGOs already had a wealth of experience in developing forest-related projects with conservation agendas before starting REDD+ projects (Simonet et al., 2015). NGOs support the REDD+ mechanism by securing funds and shaping projects in a comparative fashion (Brockhaus and Di Gregorio, 2014). Another critical feature is that many NGOs can empower local communities. For successful implementation of REDD+ projects, engaging local communities as major stakeholders is essential, but building official partnerships is sometimes hindered by licensing, incentive issues (Sills et al., 2014), and benefit sharing plans (BSPs) (Poudyal et al., 2020). For these reasons, project implementors look for NGOs with the capacity to operate community-based projects as an alternative strategy without waiting for licenses. As research results show, project networks highlight that USA-based actors dominate REDD+ partnerships in terms of number and network influence. The most influential actors in networks are largely NGOs. The project partnership networks do not actively include the global key elements as partners in project networks (Table 4): leading international organizations such as WWF, IUCN and the World Bank and key funding initiatives including the Forest Carbon Partnership Facility (FCPF), the REDD+ Partnership, UN-REDD, and the Forest Investment Programme (FIP) (Cadman et al., 2017). The results show clearly that partnership networks in REDD+ projects have a centralized structure, called “concentrated polycentricity”. Concentrated polycentric networks are spatially centralized, whereas polycentricity means a fragmented network structure with separate bodies (Abbott, 2012). This concentrated structure would cause less participation of stakeholders and perverse incentives only for key actors (Gallemore and Munroe, 2013). On the other hand, fragmentation and participation between diverse organizations in the network provide many benefits (Bardhan, 2002): facilitating cross-level interactions by sharing information and cooperation (Di Gregorio et al., 2019), solving environmental problems by developing common perceptions and synergies from working together (Österblom and Bodin, 2012). This study suggests distribution of network power and international movement towards polycentric or fragmented governance when implementing REDD+ projects encourages interaction between stakeholders.

5.2. Coordination and collaboration

Partnerships with diverse stakeholders strengthen sustainable governance and capacity to resolve problems (McAllister and Taylor, 2015). It is necessary to navigate the diverse complexities of both coordination and cooperation when solving real world problems, such as climate and environment matters (Lubell, 2013). Partnerships have diverse patterns according to purposes, characteristics and organization type (Brockhaus and Di Gregorio, 2014; McAllister et al., 2015; Nita et al., 2016). To understand how organizations are involved in REDD+ project partnerships, we used ERGMs, using two key patterns, called configurations: within-type and across-type bridging configurations. Bridging configurations represent the interactions between two actors connected to one project. Such configurations provide unbiased interpretations of complex and nested networks like the regression model. Within-type bridging can occur between actors of the same type with low risks, such as low transaction costs to deal with socially close partners (Gallemore and Jespersen, 2016). Across-type bridging makes partnerships with different types of stakeholders, which fosters the learning process from diverse kinds of partners (McAllister et al., 2015). Statistical results (Table 3 and Fig. 8) quantify configurations to explain the characteristics of partnerships in REDD+ project networks. Fig. 8 is an illustrated version of Table 3 to visually compare and emphasize the differences in actors' roles by region. Given ERGM modeling can only give a straightforward explanation, Fig. 8 intuitionally tests whether the configuration (i.e., within-type or across-type bridging) exists more or less frequently than expected (Wang et al., 2009; Wang et al., 2013; McAllister et al., 2015). Probability is interpreted as more or less likely according to whether the line is outside or inside 0 (base). For instance, Asian public organizations (Fig. 8A) are more likely to form within-type partnerships and less likely to make across-type partnerships with other kinds of organizations as the graph exists outside to the left of the base (within-type bridging) and inside the right side of the base (across-type bridging).

First, as most actors in all regions have fewer bonds across types, stakeholders may be averse to sharing and granting access to their know-how and knowledge. However, public organizations in Africa (Fig. 8A) and research institutes in Asia and South America (Fig. 8D) show more bonds than expected. International research institutions, such as CIFOR, have compiled global data about REDD+, and local research institutes have site-specific information essential for project implementation. Though research institutes have a prominent voice in modeling and standardizing REDD+ through successful partnerships with other types of organizations, they represent a relatively small portion of all actors in the networks (11%).

Second, results highlight that organizations are more likely to form within-type partnerships (Fig. 8A, B, C and E). An exception is public organizations in Africa, which are less likely to do so. This is because stakeholders may try to avoid the potential challenges of across-type partnerships, such as high transition costs (McAllister and Taylor, 2015; McAllister et al., 2015). Another reason why there are more within-type partnerships than expected is that organizations have already formed close-knit relationships with the same types of actors. They may have shared norms (“homophily”) or be geographically and administratively close to each other (Carlsson and Sandström, 2008).

Other projects in different fields show similar patterns (within-type bridging) to this research. Nature conservation and environmental and climate action projects in the EU follow within-type cooperation patterns (Nita et al., 2016). In environmental projects, actors work with the same types of organizations to avoid conflicting interests and potential risks. In the case of urban development projects, most actors are unlikely to form across-type bridging because of risks perceived by stakeholders (McAllister et al., 2015).

Potential problems here are that actors with fewer across-type partnerships have limited potential for knowledge transfer and innovation based on alliances with other organizations (McAllister et al., 2015; Nita et al., 2016). These patterns diminish opportunities for innovation and extensive knowledge sharing.

This research suggests an integrative venue where stakeholders with

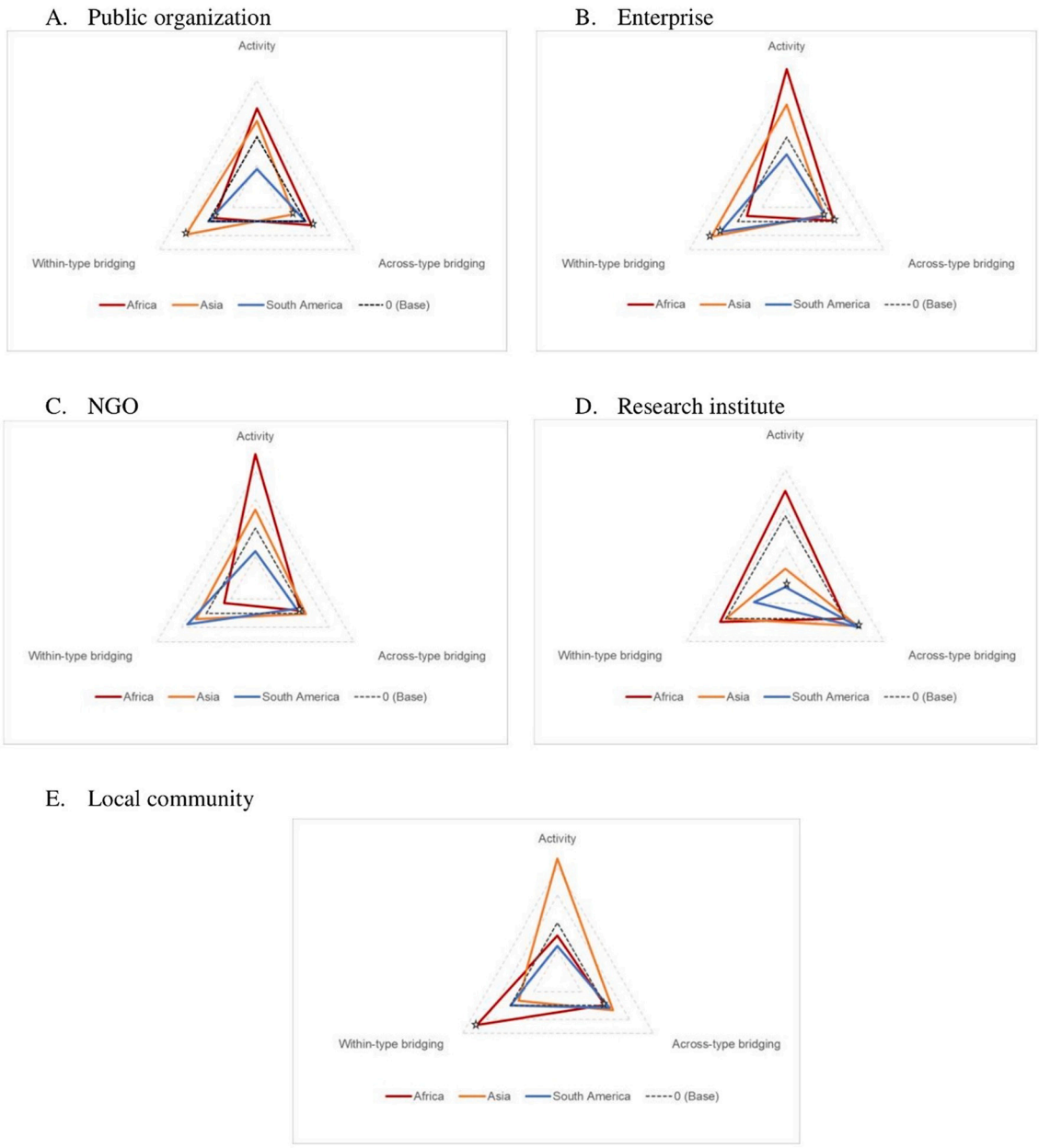


Fig. 8. Configurations by organization type.

their own goals build trust and resolve conflicts. Although there was an international attempt to scale up partnerships with the REDD+ Partnership from 2010 to 2014 (Climate Initiatives Platform, 2020), only national actors (75 countries) joined the network. The new platform is necessary for other stakeholders, including NGOs and enterprises, to share their interests and establish trust relationships with each other. Through communication, stakeholders can bridge gaps and establish confidence to meet technical and procedural requirements. The COPs of the UNFCCC, for instance, can be the ideal way by providing forums and activities, not only for public organizations, but for NGOs, private actors and local communities as well (Lesniewska, 2013).

5.3. Limitations of the REDD+ partnership network study

The research delineated the key players and predominant patterns of partnerships between stakeholders in REDD+ projects. The different social network analysis and statistical analysis (ERGM) approaches allowed us to interpret the structure of partnerships and why different actors build partnerships for REDD+ implementation. However, actors' motivations and partnership patterns are too complex to explain, and social network analyses are somewhat theoretical (La Viña and Lee, 2015). To better understand the complexities of REDD+ partnerships, qualitative research methods such as interviews and surveys were necessary for supplementing the quantitative studies. It was not possible to diagnose each individual partnership as the study only covered global- and regional-scale networks (Sánchez-Algarra and Anguera, 2013).

This research had some methodological limitations. As it depended on the ID-RECCO database, there may be ambiguities regarding the scope of REDD+ projects in this study in terms of scale, organization type, and activities. The dataset in this study is relatively inclusive, with activities including REDD, ARR, and IFM where projects conducted in developing countries have been aimed at reducing emissions from deforestation and forest degradation, whereas some researchers only look at REDD activities in REDD+ schemes, while excluding ARR activities from the scope of REDD+ projects, considering ARR to be part of

CDM (Simonet et al., 2015). In addition, we classified organizations into five groups for simplification and intuitive interpretation of the coding system. This allowed organizations to be analyzed at multiple levels: international, national, and local. The categorization of organization types was necessary for country-specific and in-depth research.

The statistical method, ERGM, only goes so far in providing straightforward explanations, given that random theory can only test whether a configuration exists more or less than expected (Wang et al., 2009; Wang et al., 2013; McAllister et al., 2015). In some of the results, the statistical degree of freedom may be too low to be conclusive as some actor types, especially local communities, were few in number (McAllister et al., 2015). Despite these limitations, this study still provides an understanding of REDD+ project networks and an overall picture of the REDD+ mechanism.

6. Conclusion

REDD+ provides a unique stage for governance and collaboration between diverse stakeholders, including states, international organizations, NGOs, research institutes and local communities. Given that partnerships between stakeholders work as bridges for resources, knowledge, and information, our research delineates the key players and predominant patterns of partnerships between stakeholders by analyzing partnerships in REDD+ projects. Global and regional network analyses (Figs. 6 and 7) reveal the centralization around core actors and actors' positions in networks for resource exchange, information flow and partnerships. The different social network analysis and statistical analysis (ERGM) approaches allowed us to interpret the structure of partnerships for REDD+ implementation. ERGMs (Table 3 and Fig. 8) configure inter- and cross-sectional networks, highlighting within-type bridging. However, centralization (concentrated polycentricity) and a tendency towards within-type collaboration can limit participation by multiple stakeholders and may cause brokers to take advantage of incentives. This trend may indicate project proponents find it challenging to communicate and cooperate with other partners. Therefore, this research suggests the need for network fragmentation (power distribution) and more diverse stakeholder participation by promoting cross-sectoral cooperation and partnership synergies to maximize efficiency and effectiveness in governance.

This study stands to improve understanding of REDD+ project networks and provide an improved global picture of the REDD+ mechanism. This comprehensive research can be a starting point for country-specific analyses and for predicting partnership performance, constraints and dissemination of information. Its results can be used as a basis for identifying a country's or institution's capacity to carry on. International and national policymakers can refer to its results to benchmark partnership potential and to formulate policies for REDD+ project implementation, as this research gives specific suggestions for network management, especially ways to link stakeholders to promote partnerships, cooperation and resilience. Understanding network patterns and structures can be the first step as a theoretical and analytical tool for future studies on natural resource management. Hopefully future research and projects will benefit from our results, which provide a comprehensive picture of the REDD+ architecture.

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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.

Appendix A. Coding category and definition

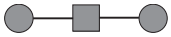
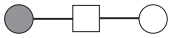
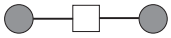
Theme	Coding category	Sub-category/Value	Definition	Example
Actor	Name	Actor name	Name of organization	Carbon Tanzania (CT)
	Role	Proponent/Partner	Organization's role in project	Partner
	Country	Country name	Country where the organization's headquarters is located	Tanzania, United Republic of
	Region	Europe/Africa/Asia/North America/Central America/South America	Region where the organization's headquarters is located	Africa
	Type	Public organization/NGO/Research institute/ Enterprise/Local community	Type of organization	NGO
Project	Title	Title	Project title	Reforestation of degraded grasslands
	Country	Country name	Country of project implementation	Colombia
	Region	Africa/Asia/South America	Continent of project implementation	South America
	Area	Hectares	Area covered by the project	3137
	Start Year	Year	Year of project commencement	2000
	End Year	Year	Year of project conclusion	2030
	Duration	Years	Period of time from project commencement to conclusion	30
	Objective	Biodiversity conservation/Climate change/ Protection indigenous people/Social development/NTFP production	Main project objective(s)	Biodiversity conservation
	Type of forest	Dry/Humid/Wetland	Type of forest in the project location	Dry
	Deforestation driver	Fire/Industrial agriculture/Industrial wood production/Illegal logging/ Cattle grazing/Infrastructure	Main driver of deforestation at the project site	Industrial agriculture
	Climate Scheme	ARR/IFM/REDD	Climate schemes	REDD
	Protected area	Yes/No	Existence of protected area in the project location	Yes
Certification	Standard	CCB/./VCS/CDM/Plan vivo/CCX/Gold Standard/FSC	Name of carbon standard applied by the project	VCS
	Status	Certified/In-process/Expired/Withdrawn	Carbon certification status	Certified
	Annual carbon credits	In tons of CO_2 equivalent	Yearly emissions reductions	32,965

(continued on next page)

(*continued*)

Theme	Coding category	Sub-category/Value	Definition	Example
	Total carbon credits	In tons of CO_2 equivalent	Total emissions reductions	988,950
	Methodology	Methodology name	Name of carbon accounting methodologies	AR-AM0004

Appendix B. T-ratio of estimation and goodness-of-fit analysis

Configurations	Category	Africa		Asia		South America	
		Estimation (t-ratio)	GOF (t-ratio)	Estimation (t-ratio)	GOF (t-ratio)	Estimation (t-ratio)	GOF (t-ratio)
Activity 	Actor-project	−3.51	−1.88	0.14	−1.89	0.92	−1.95
Bridging 	Actor-project-actor	−3.47	−1.28	0.15	−1.29	0.85	−1.29
Dummy variables							
Activity 	Public organization	−1.94	−1.89	0.10	−1.88	0.54	−1.96
	Enterprise	1.35	−1.88	0.14	−1.92	0.49	−1.94
	NGO	4.58	−1.85	−0.04	−1.87	0.23	−1.97
	Research institute	−1.05	−1.89	0.25	−1.90	0.74	−1.98
	Local community	−4.25	−1.96	−0.08	−1.86	0.46	−1.91
Across-type bridging 	Public organization	−1.82	−1.29	2.74	−1.29		
	Enterprise	−2.09	−1.29	0.09	−1.31	3.41	−1.29
	NGO	−2.31	−1.28	0.00	−1.28	1.71	−1.30
	Research institute	−1.63	−1.29	2.28	−1.30	3.32	−1.30
	Local community	−3.15	−1.30	0.50	−1.35	2.37	−1.29
Within-type bridging 	Public organization	−1.26	−1.30	3.51	−1.27		
	Enterprise	2.45	−1.28	0.07	−1.31	3.97	−1.29
	NGO	6.00	−1.27	0.32	−1.27	2.07	−1.30
	Research institute	0.03	−1.27			3.65	−1.29
	Local community	−4.22	−1.35	0.32	−1.59		

Appendix C. Reputational power of categories by region

Region	Actor type	Number of Actors	Sum of Indegrees
Africa	Public organization	88	1096
	Enterprise	69	716
	NGO	92	860
	Research institute	43	545
	Local community	7	300
Asia	Public organization	110	792
	Enterprise	79	499
	NGO	68	537
	Research institute	33	241
	Local community	4	79
South America	Public organization	66	877
	Enterprise	110	2456
	NGO	91	1252
	Research institute	27	1360
	Local community	5	96

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