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Master's Thesis of Science in Agriculture

Global Partnerships in REDD+ Mechanism

REDD+ 사업의 글로벌 파트너십 네트워크 분석

February 2021

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Global Partnerships in REDD+ Mechanism

A thesis
submitted in partial fulfillment of the requirements to the faculty
of Graduate School of International Agricultural Technology
for the Degree of Master of Science in Agriculture

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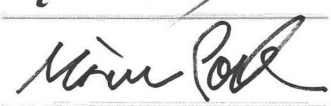
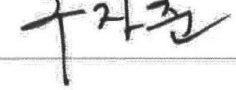
Member	**Mi Sun Park, Ph.D.**	
Member	**Ja-Choon Koo, Ph.D.**	

Abstract

Global Partnerships in REDD+ Mechanism

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Projects for reducing emissions from deforestation and forest degradation (REDD+) have been initiated in developing countries, featuring partnerships with multiple actors under the climate change regime. Even though partnerships between stakeholders are crucial for ensuring successful project delivery and outcomes, there is 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.

Keywords: REDD+, Partnerships, Social Network Analysis, Governance, ERGM, Climate Change

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List of Abbreviations

A/R	Afforestation and reforestation
ARR	Afforestation, reforestation, and revegetation
CAAC	Clean Air Action Corporation
C&B	Centro de Investigación Carbono y Bosques
CO2	Carbon dioxide
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CDM	Clean development mechanism
CCB Standards	Climate, Community & Biodiversity Standards
COP	Conference of Parties
CI	Conservation International
EU	European Union
ERGMs	Exponential random graph modeling
FFI	Flora and Fauna International
FCPF	Forest Carbon Partnership Facility
FLR	Forest Landscape Restoration
FIP	Forest Investment Program
GEF	Global Environment Facility
GiZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
GHG	Greenhouse gas
IFM	Improved Forest Management

IDESAM	Institute for Conservation and Sustainable Development of Amazonas
IFRI	International Forestry Resources and Institutes
ITTO	International Tropical Timber Organization
ID-RECCO	International database on REDD+ projects and programs linking Economic, Carbon, and Communities data
PES	Payment for ecosystem services
REDD+	Reducing emissions from deforestation and forest degradation
SNA	Social network analysis
TGC	Terra Global Capital
CIFOR	the Center for International Forestry Research
CCBA	the Climate, Community, and Biodiversity Alliance
CfRN	the Coalition for Rainforest Nations
TNC	The Nature Conservancy
VCS	the Voluntary Carbon Standard
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WCS	Wildlife Conservation Society
WWF	World Wide Fund for Nature

1. Introduction

Deforestation in developing countries is one of the causes of greenhouse gas (GHG) emissions, which can be reduced from afforestation and reforestation by capturing carbon dioxide (CO2) (IPCC, 2007). Despite the importance and potential benefits of reducing GHG emissions from deforestation and forest degradation, international agreements on forestry and climate change were not adopted until 2005 (Cerbu et al., 2011). In 2005, global efforts to reduce emissions from the forest carbon sector gained momentum for setting a new agenda item on reducing carbon emissions from deforestation (RED) at the 11th Conference of Parties (COP) under the United Nations Framework Convention on Climate Change (UNFCCC) in Montreal (UNFCCC, 2005). The new agreement was developed to combine diverse objectives from RED and REDD (Reducing Emissions from Deforestation and Forest Degradation) into REDD+, by including reducing emission from forest degradation at COP13 in Bali in 2007 and adopting the 'plus'-activities of carbon stocks at COP15 in Copenhagen in 2009 (Pistorius, 2012). Many countries, especially developed countries, have financially supported REDD+. Recipient countries and organizations have initiated hundreds of REDD+ projects, which have led diverse stakeholders to make formal and informal commitments to REDD+ (Simonet et al., 2015; La Viña and Lee, 2015).

In the REDD+ mechanism, developing countries store carbon relative to a

forest reference level and receive payments for emission reduction from deforestation and forest degradation (Angelsen and McNeill, 2012). Carbon offsets from REDD+ projects are traded in the voluntary carbon market. A range of stakeholders has interests in the REDD+ scheme and governance in other fields, such as development and environmental projects (Bulkeley and Newell, 2010). When implementing REDD+, governance by different 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 of collaboration. Creating multi-level governance with different stakeholders is a core of the REDD+ scheme (Angelsen and McNeill, 2012; Cashore, 2002).

Partnerships among 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 delivery, accountability, efficiency, and effectiveness of projects (Angelsen et al., 2018). Sometimes partnerships require high-levels of communication and transaction costs (Gallemore and Jespersen, 2016). Significantly, the REDD+ mechanism has integrated objectives between environment and development. 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 to facilitate funding, knowledge and technology transfer, mitigation actions, and capacity building. Seventy-five countries have participated in the REDD+ partnership. The partnership has activities, such as capacity building and regional coordination meetings, transparency, efficiency, and effectiveness of REDD+ activities (Climate Initiatives Platform, n.d.).

Project proponents need to shape projects with an in-depth consideration of possible activities of partners, including national states, non-governmental organizations (NGOs), enterprises, indigenous communities, and all 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 that will affect the projects (Nepstad et al., 2013; McAllister and Taylor, 2015). According to Climate, Community & Biodiversity Standards (CCB Standards) validation or verification, proponents need to cooperate with partners that have human resources or experience implementing 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 figure out how to make partnerships and strategies that fill the gaps (Verified Carbon Standard, 2019).

This transboundary and multi-level governance in REDD+ projects works through partnerships but still encounters challenges, such as a lack of information and transparency of REDD+ project implementation (Angelsen et al., 2018). Moreover, discussion of 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 been frequently discussed within adaptive governance (Lebel et al., 2006; Holling et al., 2002).

Analysis from the structure of collaborative behavior, partnership, and project implementations have been widely used to address environmental challenges around the world, such as conservation initiatives, water management, and urban development (Chen et al., 2015; Nita et al., 2016; McAllister et al., 2015; Lubell et al., 2014). Primarily, Nita et al. (2016) explored partnership networks of conservation projects in Europe, picturing how to create the networks and what patterns display collaboration within European Union (EU) LIFE Nature projects (Nita et al., 2016).

In terms of REDD+, previous literature has laid out how REDD+ mechanism has been evolved. Pistorius (2012) investigated the roots and history of REDD+ by dividing REDD+ development into three phases: the emergence of the debate; readiness and pilot activities; the governance of REDD+. Okereke and Dooley (2010) studied various proposals consistent with neoliberal principles of justice in international arena. Non-state stakeholders'

roles and how these actors have played in the development of REDD+ mechanism were also explored (Schroeder, 2010).

The global REDD+ financial network at the transnational level was examined with the REDD+ funding dataset for determining which institutions and countries were major contributors for supporting REDD+ through the social network analysis (SNA) (Kim et al., 2019). Gallemore and Munroe (2013) only explored the centralization of organizations regarding financially and technically supporting REDD+ projects. Moreover, REDD+ projects analysis informed jurisdictional approaches with the same data used in this study, the International Database on REDD+ projects and programs, linking Economic, Carbon, and Communities data (ID-RECCO) (Wunder et al., 2020). Policy network analysis related to REDD+ has been broadly conducted through interviews or surveys at the transnational level (Brockhaus and Gregorio, 2014; Fatorelli et al., 2015) and at the subnational level (Bushley, 2014; Brockhaus et al., 2014; Thuy et al., 2014; Rantala and Gregorio, 2014; Rantala, 2012; Babon et al., 2014).

Previous researches related to REDD+ projects are mostly focused on the financial network or policy network. Several studies confirmed the institutional diversity of project partnership structures. In this regard, it is necessary to understand how the governance system works and forms in REDD+ projects and which organizations are the main actors in implementing REDD+ projects.

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

2. Theoretical Background

2.1. REDD+ History

The first international debate on the ability of forests to mitigate climate change was on Kyoto Protocol at the third COP of the UNFCCC in 1997. Despite potential opportunities discussed, the dispute ended up in a failure to negotiate but eventually led to compromise for afforestation/reforestation (A/R) projects in developing countries under the clean development mechanism (CDM) in developing countries (Schulze et al., 2002). A/R projects, however, have failed to attract donors due to the agreement marked by "a lack of shared normative commitments" (Lovbrand E, 2009).

Before the official discussion of REDD+ on UNFCCC, the Coalition for Rainforest Nations (CfRN) was established to coordinate international initiatives by developing countries: 22 African countries, 10 Asian countries, 6 South American countries, 10 Caribbean and Central American countries, and 5 Oceanian countries (CfRN, 2020). CfRN was even backed by NGOs and scientists and made a critical voice on negotiations, especially during COP 11 to UNFCCC (Pistorius, 2012). Moreover, Papua New Guinea and Costa Rica are the countries that brought the RED as an agenda at COP 11 to UNFCCC for the first time (UNFCCC, 2005). In 2007, the Parties during

COP 11 in Bali broadened the Reducing Emissions from Deforestation (RED) concept to Reducing Emissions from Deforestation and Forest Degradation (REDD). With the awareness of implicit challenges such as transforming natural forests into plantation (Pistorius et al., 2011), the Parties at COP 13 included '+(plus)' activities in the negotiation. Under the definition of REDD+, three categories are depending on the 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 distinguish broadly between donors and recipients. Donors play an essential role in providing financial and technical support. They mainly consist of developed countries and non-state international institutions. On the other hand, recipients are practical actors who receive aid from donors and are in charge of overall REDD+ implementation. Recipients can be classified into national-level actors and non-state organizations according to the way to implement projects (Kim et al., 2019).

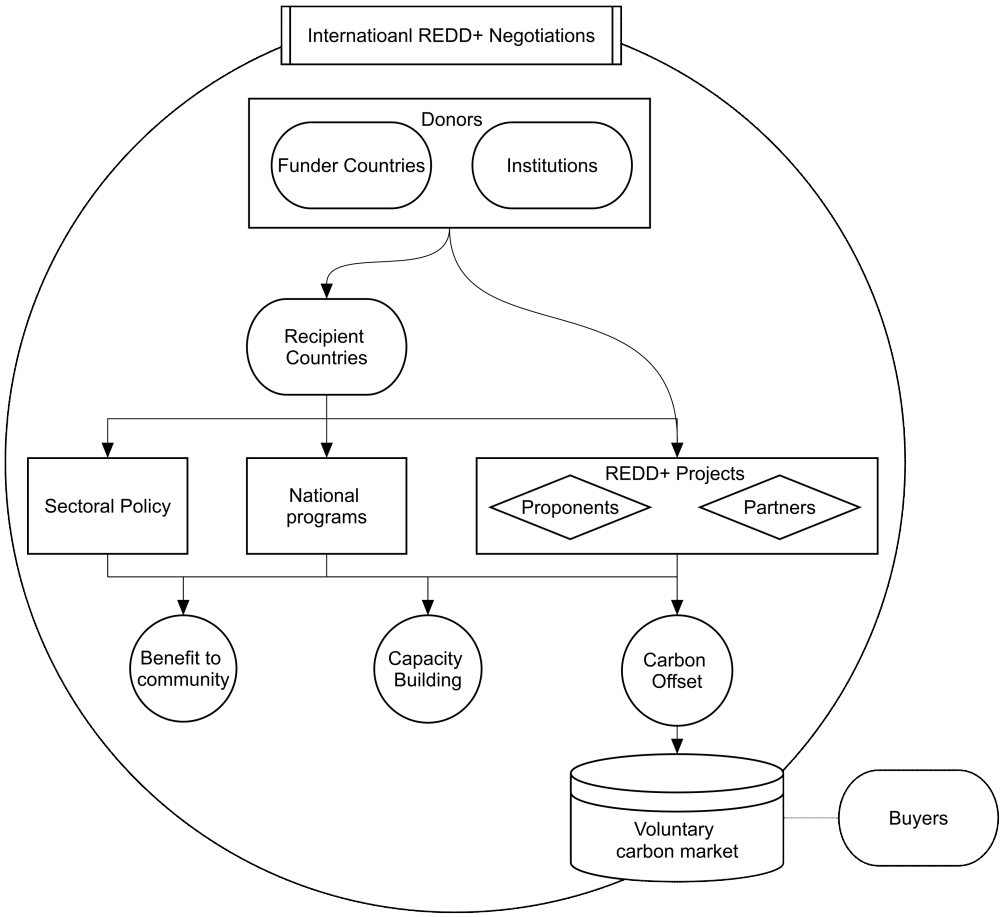
Figure 1 explains the REDD+ process from funding and implementation to compensation. The first way to implement REDD+ after financial support is the sectoral policy. Through existing sectoral administrations, a variety of external resources directly assist the regular budget. Next, national governments set policies for following REDD+ mechanism and developing independent national programs in connection with other governmental decision-making funds. Moreover, it can be defined at a multilateral level, such as subnational, jurisdictional, and provincial governments. The third case is project-based funding, where payments are mainly channeled from supporters to individual projects. This option includes specific proponents-partners structures that the external entities as an international voluntary market can engage the private sector efficiently (Vatn and

Angelsen, 2009). Since these options are interrelated, countries have to consider diverse options that fit different national REDD+ strategy components. When it comes to national-level strategy, encompassing policies for co-benefits should be set up, such as Measurement, Reporting, and Verification (MRV) system. The comprehensive process should require building an independent funding scheme (Vatn and Angelsen, 2009).

The main objectives or findings of REDD+ strategies ultimately proceed with three factors: benefit to the community, capacity building, and carbon offset (Poffenberger et al., 2009). To be more specific, the REDD+ project emphasizes the benefits for local communities. For maximizing local benefits, the government or institutions design the agreement to ensure that a large portion of net income should go directly to local communities who will operate the projects actively. As developing abilities among project participants is one of the most significant ongoing roles in the project strategies, capacity building is principal, including improving financial, technical, and organizational management skills. Financial abilities consist of fiscal planning, recording the balance contents, and managing the communities' livelihood project. Technical skills include biodiversity and socioeconomic assessment, clean and efficient energy management plan, and forest inventorying and deforestation monitoring. Lastly, organizational competencies comprise governance, formulating- policies and ordinances, and relationships with communities, districts, and local governments. By enhancing

capacity building, the projects are not only influenced directly but also it can be learning opportunities to developing countries and non-project companies (Poffenberger et al., 2009). It is clear that REDD+ projects have a common purpose of reducing carbon emissions and enhancing forest carbon stocks. However, carbon credit buyers have suffered from calculating the carbon emission reductions because of the complexity of measurement. In this regard, there have been continuous efforts to create a standard of carbon offsets, and eventually, the voluntary carbon market demonstrates substantial social and environmental credits of projects. The most well-known markets are CCB Standards, the UNFCCC CDM, and the Voluntary Carbon Standard (VCS) (Simonet et al., 2015). These credential systems of carbon offset have broadened the voluntary carbon markets and buyers as well as contributed to achieving the goals of REDD+ projects (Vatn and Angelsen, 2009).

Figure 1. REDD+ architecture



Note: modified from Simonet and Seyller (2015), Poffenberger et al. (2009), and Vatn and Angelsen (2009).

2.3. Network analysis

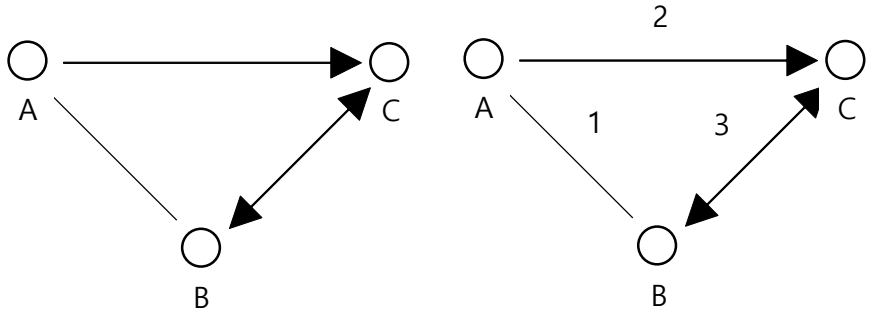
Social network analysis or network analysis examines the relationship between subjects through the intrinsic interactions (links) of subjects (nodes) in contrast to statistical analysis traditionally used in many studies (Wasserman and Faust, 1994). By deriving and visualizing the relationship and structure between subjects, which cannot be deduced by statistical methods, social network analysis allows the analysis of the network's structural characteristics and deriving new meanings (Wasserman & Faust, 1994). Each node is an actor as a subject of an action, and the links between these actors gather to form a relationship so-called “network” (Wasserman & Faust, 1994).

One of the ways to express the relationship between these actors is a graph technique called Sociogram, which consists of nodes and links. Networks are divided into a binary graph (Figure 2A) and a weighted graph (Figure 2B) according to whether the strength of the relationship is reflected. For example, in Figure 2A, if links have arrows (direction), the network is a directional network (A-C), and if no arrows, it is non-directional (A-B). Link A-C of Figure 2A is called a unidirectional graph in case of one direction, bi-directional in two directions (C-B), and non-directional network in case of no direction (A-B). As shown in Figure 2B, a graph that reflects the strength of the relationship is a weighted graph. The relationship between B and C in Figure 2B is strongest as the weight value is three. The network

of this study is binary networks, not reflecting the degree of partnership since the purpose of this study is to analyze partnerships between organizations. In detail, organizations in the same projects have the value 1, but 0 if no partnership.

Figure 2. Sociogram

A. Binary graph B. Weighted graph



Note: modified from Shin et al. (2020)

Table 1 describes centrality indexes (Degree centrality, Betweenness centrality, and Closeness centrality). Degree centrality refers to how many tie nodes connect to, which shows the number of direct connections to an individual project, organization, and country (Opsahl et al., 2010). Betweenness centrality represents how many times a node appears in the shortest paths between nodes. The higher betweenness centrality a country has, the more able a country controls the flow in the REDD+ partnership network since it funnels the interaction (information, experience, know-how, etc.) between the countries (Borgatti et al., 2018; Opsahl et al., 2010).

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 a greater power to enable the information flow as close to many other nodes (Borgatti et al., 2018; Borgatti and Everett, 1997).

Table 1. Centrality index.

Network Index	Formula	Definition	Meaning
Degree centrality	$C_D^{\in}\left(d_i^{\omega}\right)=\frac{1}{N-1}\sum_{j=1}^{N} d_{ij}^{\omega}, i \neq j$ $C_D^{OUT}\left(d_i^{\omega}\right)=\frac{1}{N-1}\sum_{j=1}^{N} d_{ij}^{\omega}, i \neq j$	how many tie nodes connect to	Ability to attract partnership.
Betweenness centrality	$B_m=\frac{\sum_{k=1}^{N}\sum_{l=1}^{N}\frac{g_{kml}}{g_{kl}}}{\frac{(N-1)(N-2)}{2}} \quad Only, k<l, k \neq l$	Number of shortest paths that pass through a node.	Important role in the network flow.
Closeness centrality	$Cxl=\frac{1}{\frac{1}{N-1}\sum_{N \neq l} l_{xl}}$	Proportional to the total geodesic distance to all other nodes in the respective set.	Influenceof the information flow.

Note: $C_D^{\in}\left(d_i^{\omega}\right)$ is in-degree centrality of i^{th} and $C_D^{OUT}\left(d_i^{\omega}\right)$ means out-degree centrality.

The shortest path between node k and node l is g_{kl}, the number of nodes in g_{kl} is g_{kml}.

l_{xl} represents the shortest distance between node x and node l.

3. Data and Procedure

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, but also 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, and the dataset in a 2-mode network, however, 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 is project partners.

Quantifying network metrics is the key to answer which countries and which types of organization, are the most dominant and efficient to control communication in the REDD+ partnership network at the global and regional level (Bonacich, P., 2007). As a statistical network method, exponential random graph modeling (ERGM) shows the pattern to create partnerships between different organization categories. In this way, the results help to understand and map the comprehensive pictures of large-scale complex

networks of REDD+ projects (Boccaletti et al., 2014).

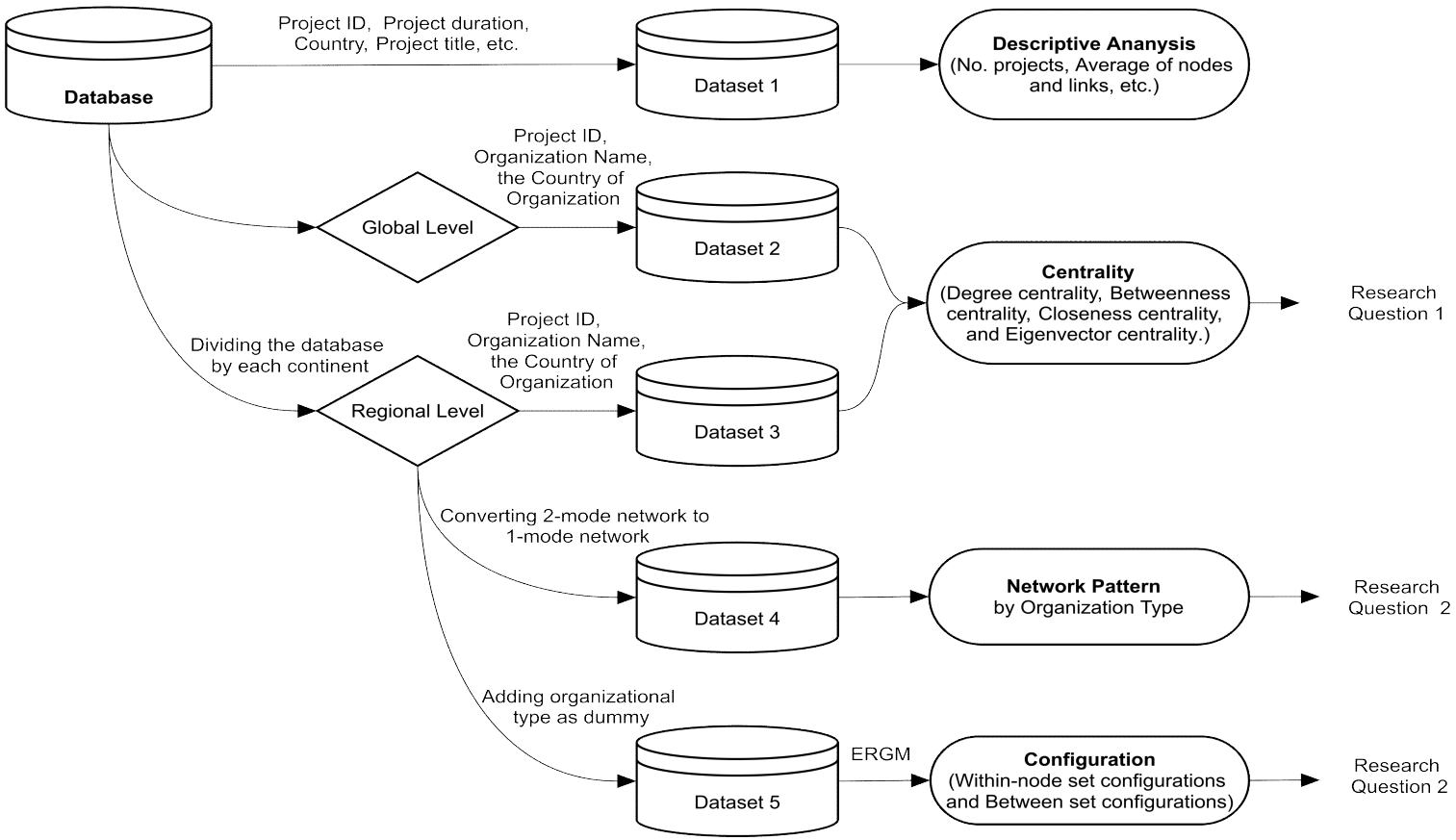
In this regard, this study addresses the following research questions by using social network theory:

Research Question 1. Which countries and organizations/Which type of organizations are dominant and influential in REDD+ partnerships when implementing projects at the global level and regional level?

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 steps of analyses: centrality analysis at the global and regional level to answer Research Question 1, network pattern analysis to answer Research Question 2, and statistical network modeling (ERGMs) analyses (configurations) to answer Research Question 2 (Figure 3).

Figure 3. Conceptual Framework



3.2. Data

The dataset used in the study contains 523 REDD+ projects and programs in 57 countries. Technically, the datasets consist of REDD+ 467 projects from the ID-RECCO database, the International Database on REDD+ projects and programs, ID-RECCO data. Then, the up-to-date 56 projects were updated more from the same sources (Appendix 1), where ID-RECCO collected REDD+ project data. The key source of the database (Appendix 1) is project documents designed for certification of the voluntary carbon market to sell carbon offsets, including VCS, CDM, Plan Vivo, the Climate, Community, and Biodiversity Alliance (CCBA) (Simonet et al., 2015). ID-RECCO is a joint work in the collaboration, 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 International Forestry Resources and Institutes (IFRI, University of Michigan, USA) by 2018, and after then, CIFOR, 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 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 till 2015 (Simonet and Seyller, 2015),

Simonet et al. (2018) created a central database that tracks REDD+ projects worldwide for global analyses (Simonet et al., 2018). 43 (terminated, abandoned, or planned projects) were excluded, so 480 projects are finally included.

The network dataset for social network analysis consists of projects and organizations linked in the project (Wasserman and Faust, 1994). In the coding process, the main data extracted from each project was the project ID, organization name, organization type, country, and the continent of the origin of each organization, project duration, and project title (Table 2). Then, organization names were double-checked and standardized to avoid duplication errors. The organizations were classified by four categories as legal status: public organization, NGO, research institute, enterprise, and local community.

Table 2. Coding category and definition.

Theme	Coding category	Sub-category/Value	Definition	Example
Actor	Name	Actor name	Name of the organization	Carbon Tanzania (CT)
	Role	Proponent/Partner	Role of the organization in project	Partner
	Country	Country name	Country where the headquarter of the organization is located	Tanzania
	Region	Europe/Africa/Asia/North America/ Central America/South America	Continent where the headquarter of the organization is	Africa
	Type	Public organization/NGO/ Research institute/ Enterprise/ Local community	Type of the organization	NGO
Project	Title	Title	Title of the project	Reforestation of degraded grasslands.
	Country	Country name	Country where the project has been implemented	Colombia
	Region	Africa/Asia/South America	Continent where the project has been implemented	South America
	Area	Hectares	Area where the project covers	3137
	Start Year	Year	Year when the project started	2000
	End Year	Year	Year when the project will be end/was end	2030

	Duration	Years	Periods from the time the project starts to the moment it is completed	30
	Objective	Biodiversity conservation/Climate change/ Protection indigenous people/Social development/Non-timber production	Main objective of the project	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 among REDD, ARR, and IFM	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 which the project applied	VCS
	Status	Certified/In-process/Expired/Withdrawn	Carbon certification status	certified
	Annual carbon credits	In tons of CO2 equivalent	Yearly emission reductions	32965
	Total carbon credits	In tons of CO2 equivalent	Total emissions reductions	988950
	Methodology	Methodology name	Name of carbon accounting methodologies	AR-AM0004

3.3. Network analysis

For analyses, the initial dataset was rearranged as bipartite networks (2-mode). One node is REDD+ projects, and the other is proponents and partners participating in the same REDD+ projects. According to the number of each node, n-by-m matrix was created without weight. A link between project and organization in the same REDD+ project values 1 and 0 if no link (Wang et al., 2009). For bipartite networks analysis, most calculation and visualization of the metrics were conducted using NetMiner software 4.0 (Cyram, 2013), and MPNet was used for statistical analysis (ERGM) (Wang et al., 2014).

3.3.1. Centrality

In response to research question 1, Dataset 2 and 3 were built to examine the centrality of each organization and country in the REDD+ project network at the global level and regional level. For regional-specific network analysis, the original dataset was filtered by each continent where REDD+ projects have been mostly implemented: Africa, South America, and Asia. First, the datasets mainly have project ID, the name of the organization, and the location of the headquarter (country) to design two sets of metrics: project ID and the name of the organization, project ID, and the location of the headquarter. Then, centrality indexes were calculated such as degree centrality, betweenness centrality, and closeness centrality of each node (Table 1)

(Opsahl et al., 2010; Bonacich, 2007). Interpretation of centrality measures at both global and regional level would be similar, but region-specific properties at the regional level.

3.3.2 Network pattern

For Research Question 2, block modeling is used to identify and analyze the contribution of the organizational category to network structure. Following block modeling procedures, actors were divided into five blocks as an organizational category (Public organization, NGO, Research institute, Enterprise, and Local community) (Wasserman and Faust 1994). As interested in partnership patterns between organizations, individual actors were re-coded according to five organization types. Then, a new network between organizations in the same project was built from bipartite network between project and organization. In other words, Dataset 3 (two-mode, organization-project) was converted to Dataset 4 (one-mode, organization-organization) based on the organizational types to map the patterns of the network across five blocks (Borgatti and Everett, 1997). The power of blocks varies according to the indicator, the reputational power of the actor, which is simply calculated by the sum of indegrees divided by the number of possible links of the block (Brockhaus and Gregorio, 2014). It is better to use this measure than the average indegree of all actors because the former indicator exhibits the overall power of blocks, and the latter indicator

as a sensitive measure might underestimate the large blocks (Kriesi et al., 2006).

Drawing on Kriesi et al. (2006), the reputational power was calculated by the following equation:

$$R_p = \frac{\sum_{i=1}^{n_p} id_i}{n_p(n-1)}$$

Where,

R_p represents the reputational power;

p denotes organizational category, and p = 1, 2, 3, 4,5;

id_i is the indegree of actor i in p;

n_p denotes the number of actors in p;

n is the number of all actors.

3.3.3. Configuration

The model used in the study is ERGM (p* models) to calculate the probability of REDD+ partnership network structure and understand which type of partnership arise within the continents (Research Question 2)
(Wang et al., 2009; Wang et al., 2013). Dataset 5 with dummy values was developed for each organization type to figure out the structural

configurations by categories: public organization, NGO, research institute, enterprise, and local community. If the attribute of the category is present, the value is 1. Otherwise, it is coded as 0. This study analyzed the matrix of Dataset 5 using MPNet (Wang et al., 2014).

Based on configuration statistics, the selected graphs have probability by ERGMs. The generalized form of ERGMs is following (Wang P., 2013):

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

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 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, ERGMs with bipartite networks estimate a variety of structural configurations such as star configurations, alternating stars, and edge cycles. Besides, 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 P., 2013). To find the

adequate fit of the model, the study first ran the model with the selected network configurations by using MPNet. If the t-ratios in estimation were smaller than 4 for all values, this study increased the multiplication factor and reran the model until t-ratios have small enough value (Appendix 2) (Koskinen and Snijders, 2013). Then, this study analyzed a Goodness-of-Fit of the converged models by comparing the observed model to estimates from the converged model with 100 million simulations (Wang et al., 2009), which shows and assesses how well the estimated statistics fit. Only when t-ratios in absolute values were smaller than 2, this study presents the model statistics (Appendix 2) (Wang et al., 2014).

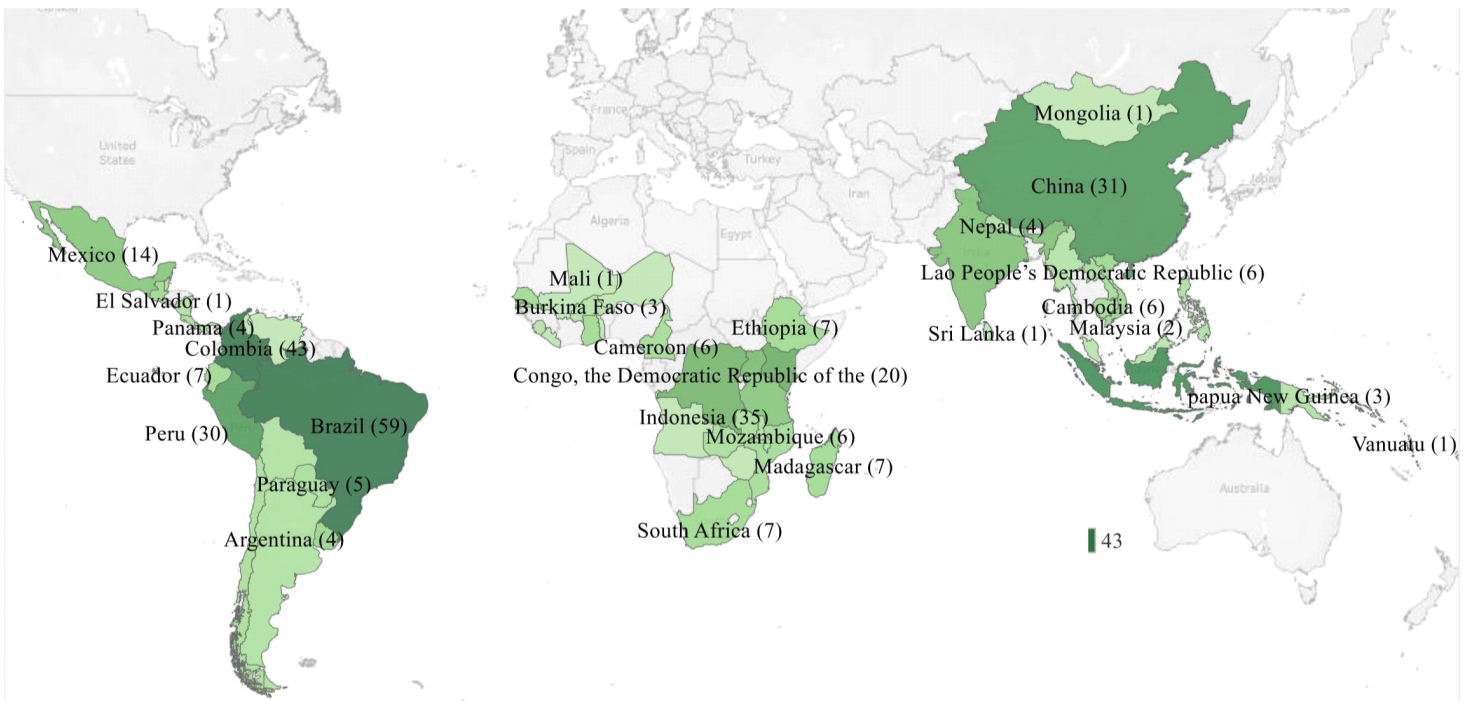
4. Result

4.1. Descriptive analysis

Several studies have 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. The results provide up-to-date information on REDD+ projects collected by June 2020 (Figure 4). 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. Especially from previous studies (Cerbu et al., 2011; Simonet et al., 2015), China did not appear with a large number of REDD+ projects. For example, Cerbu et al. (2011) categorized China as a country with less than 15 projects. However, Figure 4 shows that China takes the third rank in implementing and certifying REDD+ projects. At the regional level, 43% of all projects have been implemented in South America, 30% in Africa, and 25% in Asia. There would be the linkage between the number of REDD+ projects and the characteristics of countries such as a vast space of humid forests as a possible generator of carbon offsets (Simonet et al., 2015).

Figure 4. Geographic distribution of global REDD+ projects in developing countries

N=480



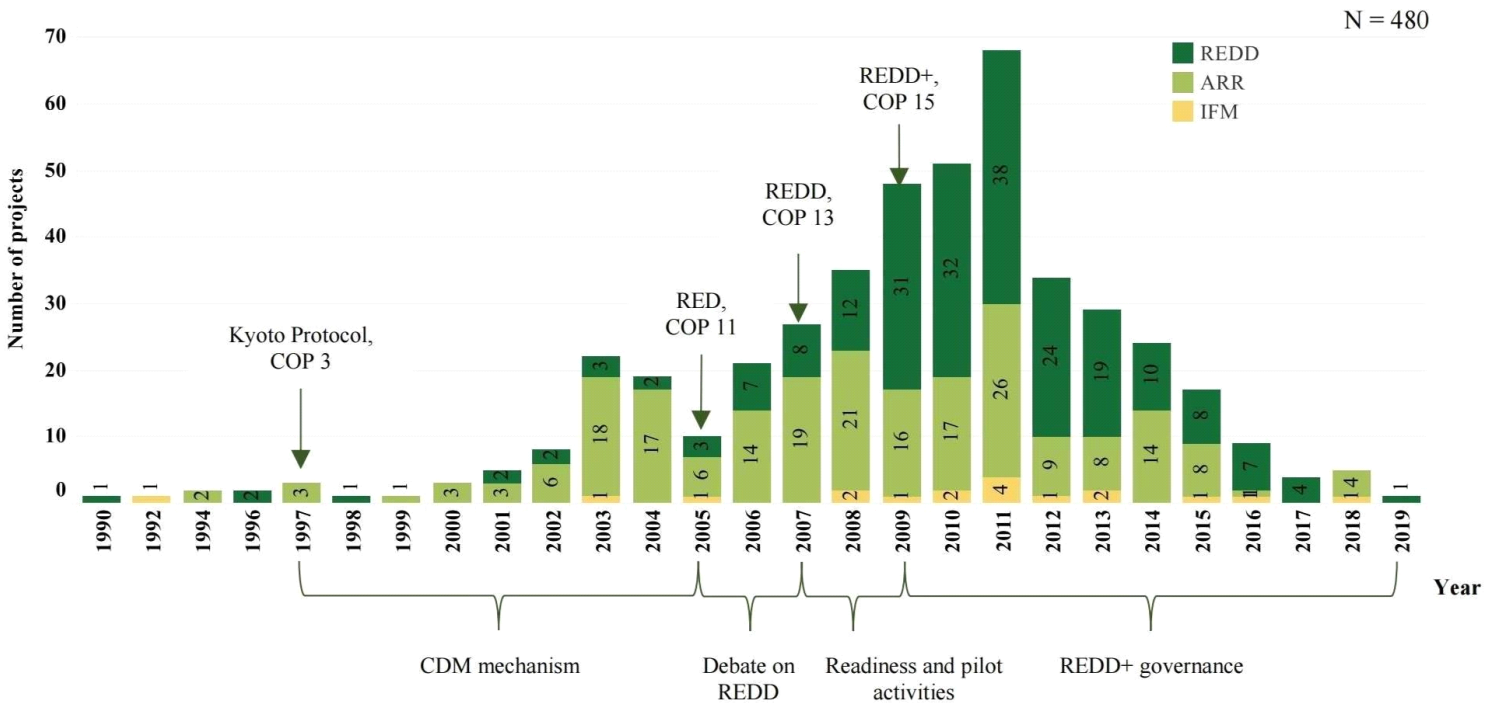
Note: The darker the green color, the higher the number of the REDD+ project implementation.

Figure 5 shows that REDD+ projects and international agreements on climate change have been positively correlated. To be more specific, ARR projects have been implemented since the first phase started (CDM mechanism) under the Kyoto protocol adopted at COP 3 in 1997. Even though ARR projects were under the CDM mechanism at first, these projects became a part of REDD+ as certified for voluntary carbon markets.

Numerous countries and institutions came forward to create REDD projects since the RED discussions at COP 11 in 2005. The downtrend of REDD+ implementations was observed after 2012 in line with the uncertainty and difficulties of financing, especially in the European markets (Simonet et al., 2015). Although some countries, such as China, started self-supported REDD+ projects with regional partners, the number of REDD+ projects which were newly established decreases recently.

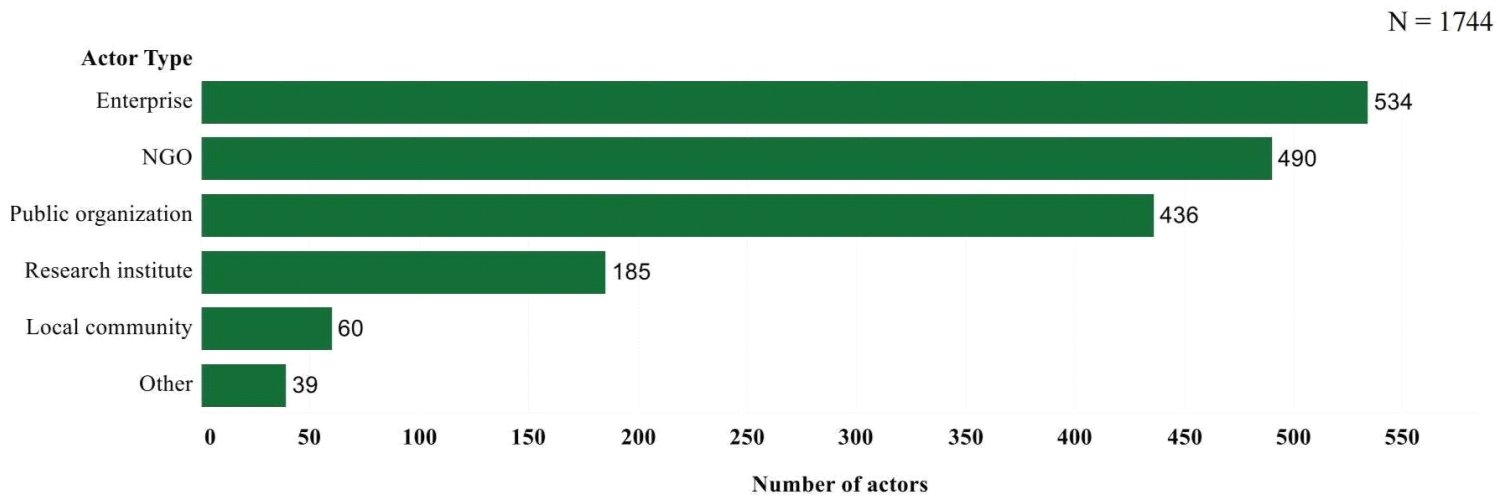
In the database, 1744 project stakeholders have participated in REDD+ projects (Figure 6). The largest group of them is enterprises (30%) as looking for the chances of capital-generating carbon markets, and the other large majorities are NGOs (28%) for conservation and the public organizations (25%) (Simonet et al., 2015). Relatively, research institutes (10%) and local communities (3%) have a smaller portion.

Figure 5. The number of REDD+ projects newly initiated in developing countries



Note:
1. Year represents the first year when the project started to be implemented.
2. COP (Conference of Parties), ARR (Afforestation, reforestation, and revegetation), and IFM (Improved Forest Management)

Figure 6. Actor types in REDD+ projects



Note: The darker the green color, the higher the number of the REDD+ project implementation.

4.2. Centrality

4.2.1. Global Level

With Dataset 2, the country-by-country analysis and stakeholder analysis were performed at the global level. In the country-by-country analysis (Figure 7A), one set of the network is project ID, and the other set is the location of the headquarter of each organization. The nodes in developed countries were marked with stars, and the nodes in developing countries were marked with triangles. In the analysis of individual stakeholders (Figure 7B), the network comprises of project ID (one mode) and stakholders (the other mode). This study noticed that stakeholders work as a proponent and as a partner in other projects. So, the network expresses project proponents in the squares and partners in the circles.

The country-by-country network (Figure 7A) shows that nodes are grouped by continent, and nodes of developing countries such as European countries are located at the heart of the network, forming partnerships with stakeholders from various countries. Specifically, USA is the most powerful country not only among developing countries as supporters, but also in the whole network, having the highest centrality values (Degree centrality: 0.344, Betweenness Centrality: 0.589, Closeness Centrality: 0.472, and Eigenvector Centrality: 0.393) (Appendix 3). It means that American partners are

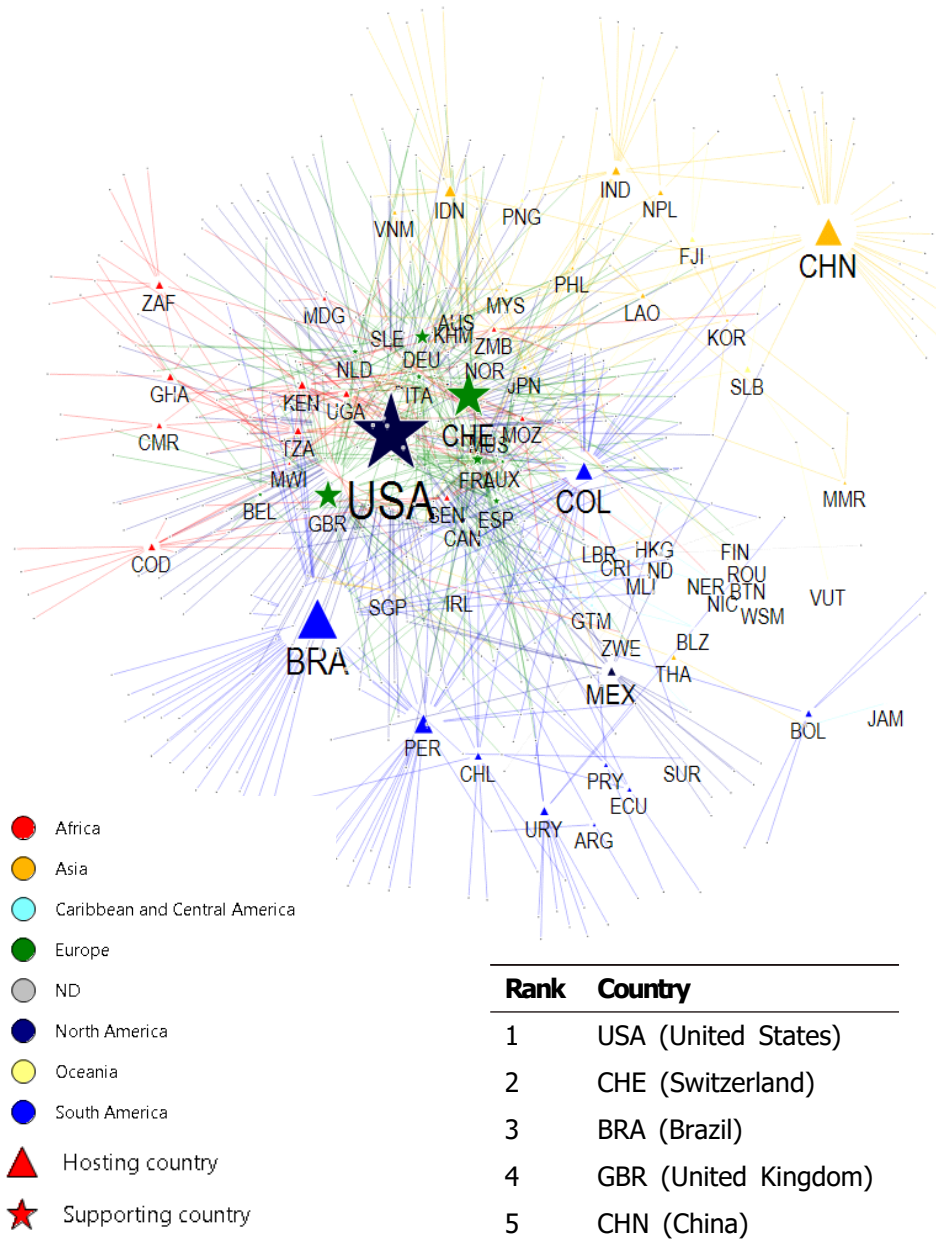
connected to influential organizations from other countries (eigenvector centrality) (Bonacich P., 2007) and play a significant role in controlling (betweenness centrality) and enabling (closeness centrality) interactions, including partnership, sharing knowledge, and communication within REDD+ projects network (Borgatti et al., 2018; Borgatti and Everett, 1997; Opsahl et al., 2010). Among developing countries as hosts of the projects, Brazil, China, Peru, Colombia, and Indonesia have successfully attracted many REDD+ projects. Brazilian partners have a relatively higher betweenness index (0.131) than others. The value of closeness centrality is similar to other hosting countries (Brazil: 0.335, China: 0.301, Peru: 0.320, Colombia: 0.324, and Indonesia: 0.309) (Appendix 4).

In the network of individual stakeholders (Figure 7B), actors in the network make groups by region like country-by-country analysis (Figure 7A). North American and European partners are usually in the center of the network, but some with regional-specific partnerships are located in that region. 7 out of the top 10 stakeholders with high betweenness centrality are NGO (Appendix 5). Nine actors of top 10 have their headquarters in developed countries, especially USA (6 organizations) (Figure 7B, Appendix 5). Organizations such as Conservation International (CI), World Wide Fund for Nature (WWF), and Wildlife Conservation Society (WCS) have been central as project proponents. Institutions such as the Nature Conservancy and United States Agency for International Development (USAID) play an

essential role as partners.

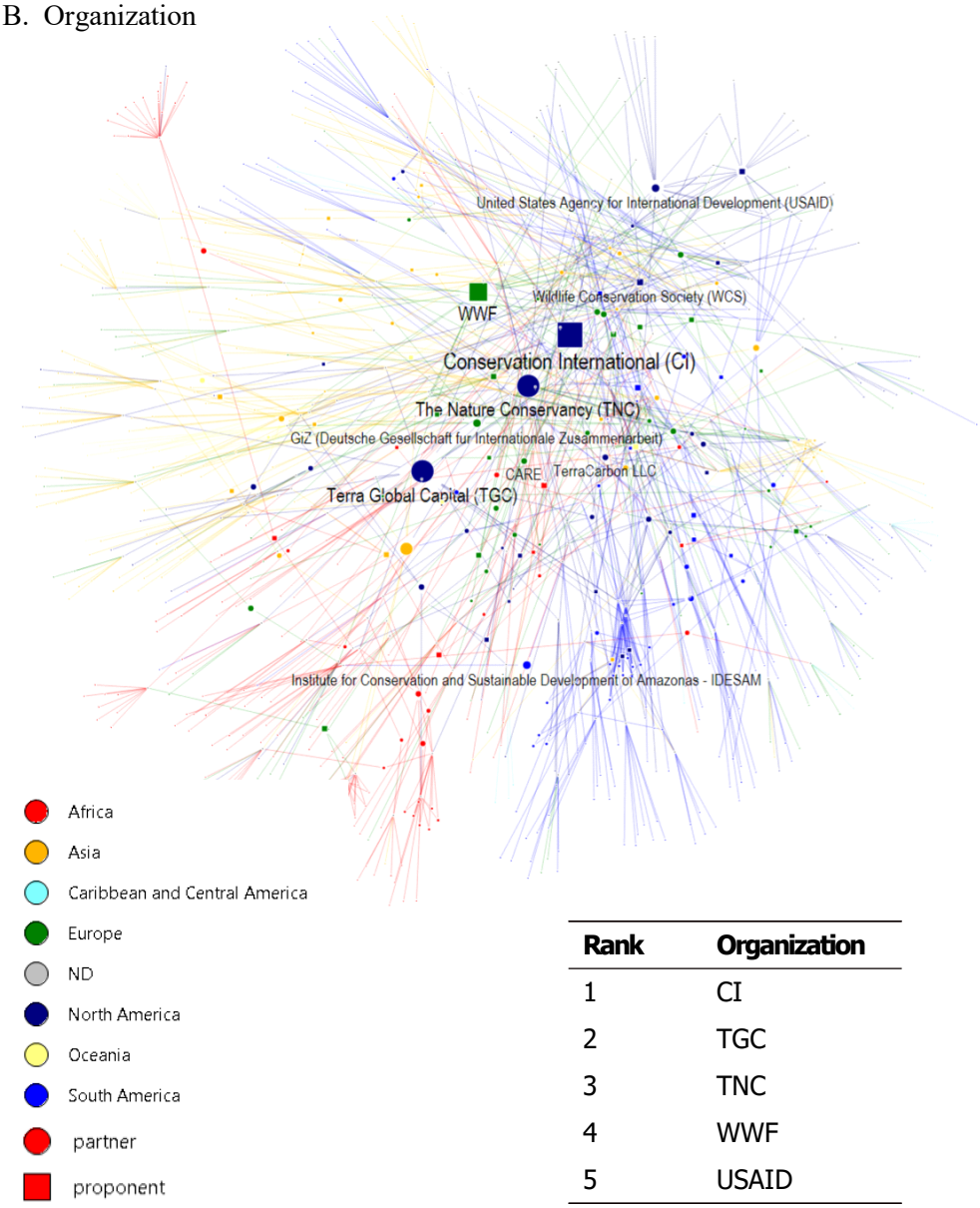
Figure 7. Global REDD+ projects partnership network

A. Country



Rank	Country
1	USA (United States)
2	CHE (Switzerland)
3	BRA (Brazil)
4	GBR (United Kingdom)
5	CHN (China)

B. Organization



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

Note:

1. Network A by country (rectangle: hosting countries and star: supporting countries) and network B by organization (circle: partner and square: supporting countries).
2. 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: Dark Green; Oceania: Yellow; and South America: Blue).
3. The size of the nodes was divided by the measure of the betweenness centrality.
4. CI (Conservation International), TNC (The Nature Conservancy), WWF (World Wide Fund for Nature), and USAID (United States Agency for International Development)

4.2.2. Regional Level

With Dataset 3, regional-specific network analysis was conducted by continent: Africa, South America, and Asia. Regional level analysis also includes the country-by-country analysis (Figure 8A, 8B, 9C) and stakeholder analysis (Figure 8D, 8E, 8F) like previous analysis at global level (Figure 7A, 7B). Country-by-country analysis (Figure 8A, 8B, 9C) uses project ID (one mode) and the location of the headquarter of each organization (the other mode). In the stakeholder analysis (Figure 8D, 8E, 8F), project ID and stakeholders connected to the project are used to build the network by region. Then, each country and stakeholder will be sized according to calculated centrality indexes.

In Africa (Figure 8A and D), the network of the REDD+ project is centered on USA, UK, and Switzerland as supporting countries and WCS, Care International, WWF, and United Nations Development Programme (UNDP) are the most active organizations with high centrality values in Africa (Appendix 6). Among hosting countries, Uganda and Kenya are the most prosperous countries attracting many REDD+ projects (Appendix 7).

The Asian network (Figure 8B and E) shows that among supporting countries some countries such as USA, Switzerland, and Germany play a significant role, and key players are World Education Inc., GiZ (Deutsche Gesellschaft fur Internationale Zusammenarbeit), the Nature Conservancy

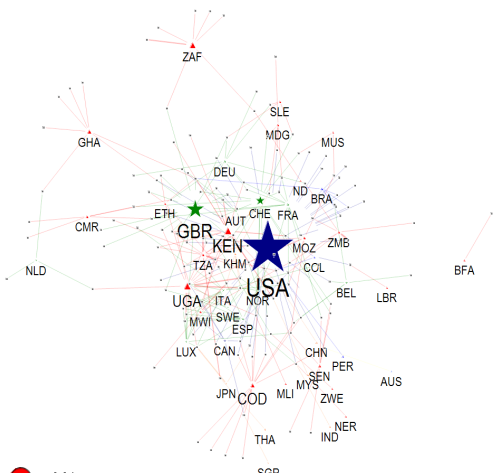
(TNC), Flora and Fauna International (FFI), and WWF (Appendix 8, 9). Most REDD+ projects have been implemented in China and Indonesia as hosting countries. The remarkable feature is that China is located outside of the network, not in the center, even with high centrality indexes (Figure 8B).

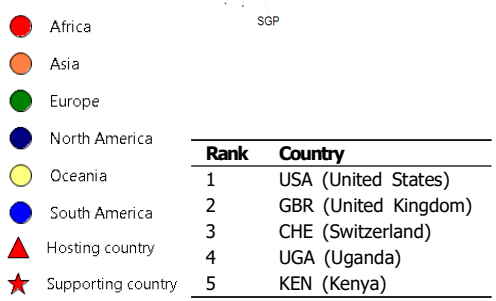
In the network of South America (Figure 8C), vital supporting countries (USA, Switzerland, and UK) are the same as in Africa. However, key individual partners are different from other regions (Figure 8F): CI, TNC, and Terra Carbon LLC. Three countries, including Brazil, Peru, and Colombia, are major hosting countries with high centrality values (Figure 8C, Appendix 10, 11).

Overall, the USA-based stakeholders dominate the network in all regions, but dominant organizations differ from region to region. For example, Wildlife Conservation Society (WCS) is centered in Africa, World Education Inc. in Asia, and Conservation International (CI) in South America (Figure 8D, 8E, and 8F). In other words, particular institutions are not central to the all continents, but each region has different key players and patterns.

Figure 8. Regional REDD+ projects partnership network by continent

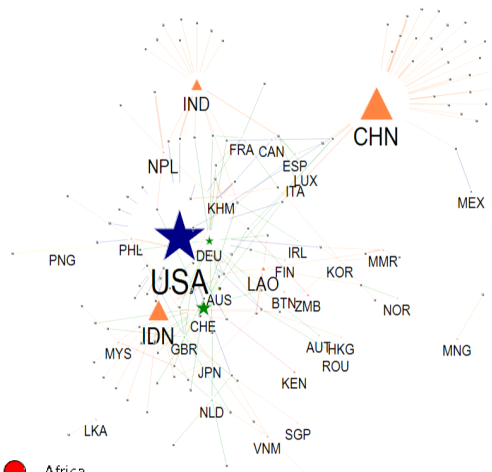
A. Country - Africa

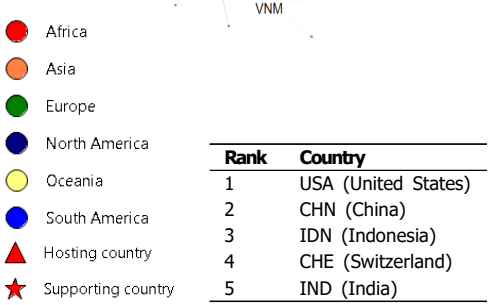




Rank	Country
1	USA (United States)
2	GBR (United Kingdom)
3	CHE (Switzerland)
4	UGA (Uganda)
5	KEN (Kenya)

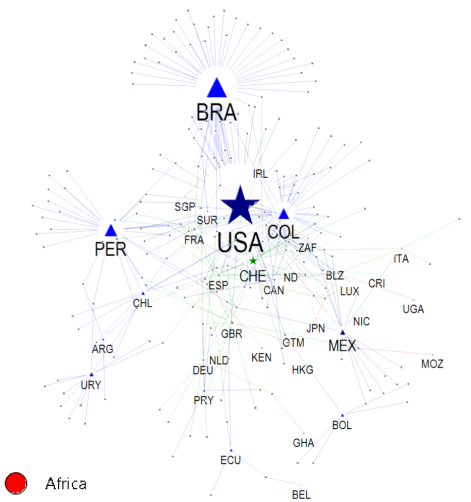
B. Country – Asia

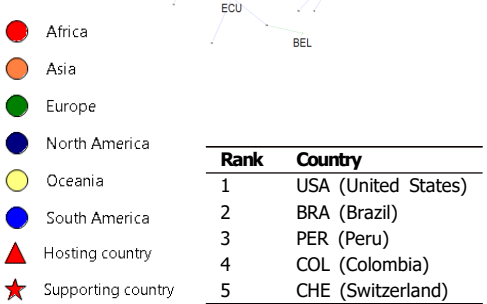




Rank	Country
1	USA (United States)
2	CHN (China)
3	IDN (Indonesia)
4	CHE (Switzerland)
5	IND (India)

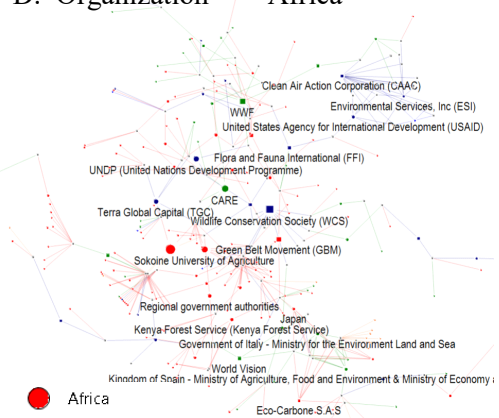
C. Country – South America





Rank	Country
1	USA (United States)
2	BRA (Brazil)
3	PER (Peru)
4	COL (Colombia)
5	CHE (Switzerland)

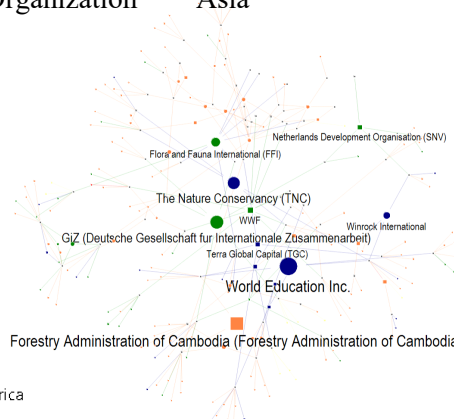
D. Organization – Africa



Africa
Asia
Europe
North America
Oceania
South America
partner
proponent

Rank	Organization
1	WCS
2	CARE
3	Sokoine University
4	WWF
5	UNDP

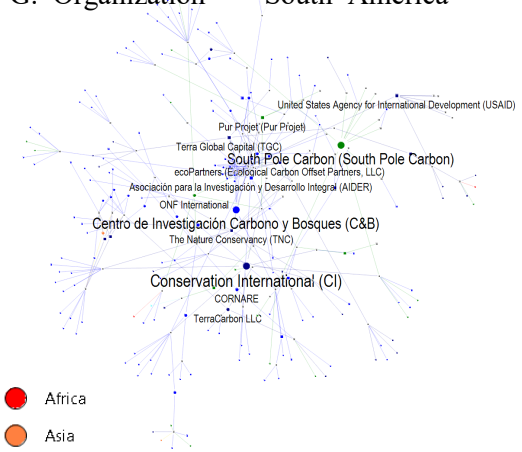
F. Organization – Asia



Africa
Asia
Europe
North America
Oceania
South America
partner
proponent

Rank	Organization
1	World Education
2	FAC
3	GiZ
4	TNC
5	FFI

G. Organization – South America



Africa
Asia
Europe
North America
Oceania
South America
partner
proponent

Rank	Organization
1	CI
2	South Pole Carbon
3	C&B
4	TNC
5	CORNARE

Note:

1. A ~ C: regional networks by countries (rectangle: hosting countries and star: supporting countries) and D ~ F: regional network by actors (circle: partner and square: supporting countries).
2. 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: Dark Green; Oceania: Yellow; and South America: Blue).
3. The size of the nodes was divided by the measure of the betweenness centrality.
4. 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) and C&B (Centro de Investigación Carbono y Bosques), FAC (Forestry Administration of Cambodia).

4.3. Network Pattern

This study grouped actors by the type of actors and built four blocks in each region (Figure 9). Blocks range in size depending on the number of indegrees to a block, and the width of the arrows indicates the number of links as well (Table 3). The more partnership with the organization type of the block form, the bigger the size of the corresponding block gets, including within-type partnerships.

The partnership patterns show that public actors have the tremendous power of partnerships with lots of connections to NGOs in Africa (Figure 9A) and Asia (Figure 9B), yet private organizations are dominant in South Africa, mostly partnered with research institutes (Figure 9C). Private actors and research institutes have relatively less power in Africa and Asia than in South America, whereas public organizations are weak in South America. Overall, within-type cooperation is active in all regions (Figure 9A, 9B, 9C).

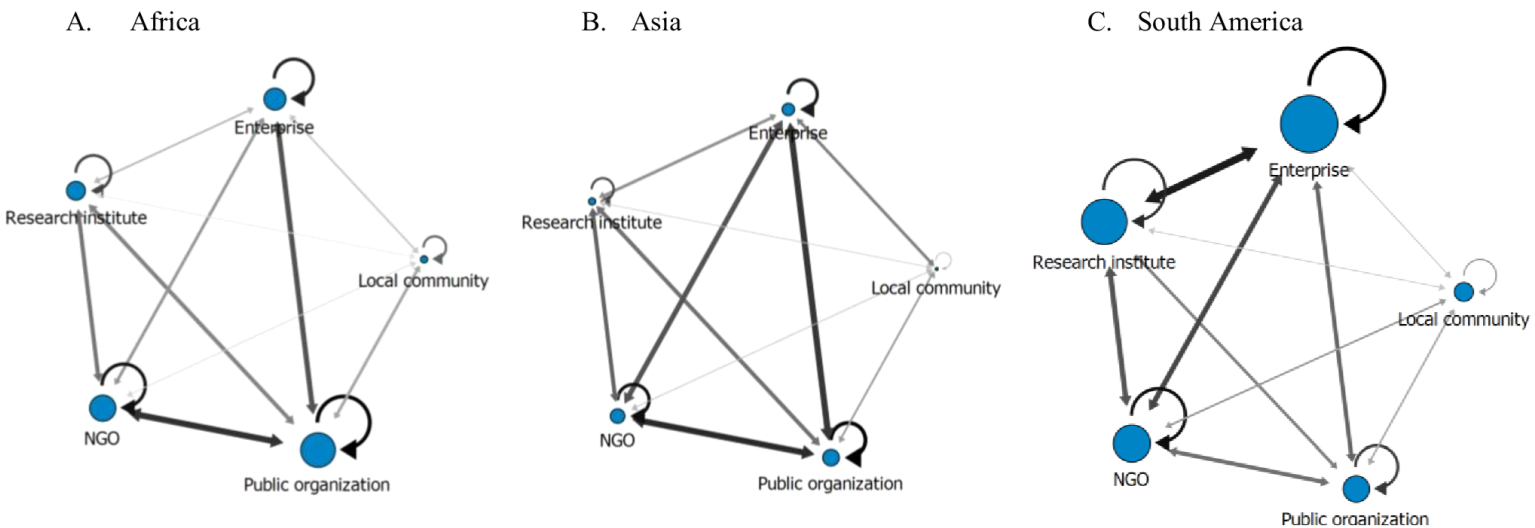
The number of stakeholders of each region is similar (Africa: 299, Asia: 294, and South America: 299), but South America has more partnerships than in the other regions (Table 3). It indicates that actors, when implementing REDD+ projects in South America, tend to cooperate with a number of partners than in Africa or Asia. This study also computed the reputational power of each block. The local community is the most potent type of organizations in Africa and Asia, and research institutes are in South

America. However, the sample size should be similar and large enough to guarantee an accurate comparison of reputational power (Kriesi et al., 2006).

Table 3. Reputational power of categories by region

Region	Actor type	Number of Actors	Sum of Indegrees	Reputational Power (R_n)
Africa	Public organization	88	1096	0.042
	Enterprise	69	716	0.035
	NGO	92	860	0.031
	Research institute	43	545	0.043
	Local community	7	300	0.144
Asia	Public organization	110	792	0.025
	Enterprise	79	499	0.022
	NGO	68	537	0.027
	Research institute	33	241	0.025
	Local community	4	79	0.067
South America	Public organization	66	877	0.045
	Enterprise	110	2456	0.075
	NGO	91	1252	0.046
	Research institute	27	1360	0.169
	Local community	5	96	0.064

Figure 9. Partnership patterns of actors in REDD+ project partnerships



Note: The size of blocks depends on the sum of the indegrees of category.

4.4. Configuration

Using ERGM, this research figures out whether configurations (e.g., within-type and across-type partnership) appear more or less than it could be statistically formed 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 to compare with the observed. In other words, through the statistical process, ERGMs help explain the process of the overall network and draw rigorous and unbiased interpretations about the abundance of configurations without a comparison of multiple networks.

The ERGMs have bipartite configurations across regions and organization categories (Table 4). Two main configurations are activity and bridging configurations. Activity configurations are the number of connections between actors and projects (Wang et al., 2009). Bridging arrangements represent the interactions between two actors that are connected to one project. In all regions, fewer activity configurations are observed than by chance. Projects implemented in Africa tend to have fewer bridging structures than expected by chance, but in Asia and South America. Thus, organizations have a lower propensity to attract many projects than expected by chance. This tendency suggests that REDD+ projects still have a limit to attract many partners. Activity estimates of each organization type are not statistically significant, but only research institutes in South America have fewer activity levels. The

tendency for organizations to have within-type bridging and across-type bridging differs from organization categories and regions. Overall, the configurations between within-type and across-type show the opposite aspect. For example, public actors in Africa have a higher tendency of across-type bridging, but they are less likely to make partnerships with the same type of organizations. On the other hand, in Asia, there are fewer partnerships of public actors with other organizations, but more in within-type bridging. The details of the configurations will be explored in the discussion.

Table 4. Exponential Random Graph Models (ERGMs) for REDD+ project partnerships

Configurations	Category	Africa		Asia		South America	
		More/Less than chance	Parameter (SE)	More/Less than chance	Parameter (SE)	More/Less than chance	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)***
Activity (Dummy)	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 (Dummy)	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 (Dummy)	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)	-	-

5. Discussion

This research examined the global networks (Figure 7) and regional networks (Figure 8) of REDD+ projects based on the partnerships between five organization types. REDD+ partnerships have successfully improved REDD+ actions against climate change as an informal forum for collaboration and communication to enhance transparency, shared knowledge, understanding, trust, and capacities on REDD+ issues (La Viña and Lee, 2015). The cooperation in REDD+ projects has different structures and patterns according to regions and organization types, which consequently lead to the overall shape of REDD+ project partnerships. As partnerships offer leverage for diverse stakeholders to govern (McAllister and Taylor, 2015), the 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

To answer Research Question 1:

RQ1. Which countries and organizations/Which type of organizations are dominant and influential in REDD+ partnerships when implementing projects at the global level and regional level?

During the development of the REDD+ mechanism (Figure 1), there have been efforts to figure out who has the greatest power and who leads the REDD+ system, but centralization patterns of the whole REDD+ architecture are still ambiguous (Gallemore and Munroe, 2013). The results indicate that numerous stakeholders from both developing and developed countries have participated in REDD+ projects with different interests, but a few central actors have enormously contributed to REDD+. Central organizations in advantageous positions of networks have influence and power as leverage or brokerage for resources and knowledge (Vinke-de Kruijf, 2013; McAllister and Taylor, 2015). Especially, project developers and partners who display distinct interests choose the target region and country according to the nature of organizations (Simonet et al., 2015). For example, the International Centre for Integrated Mountain Development (ICIMOD) supports the projects targeting the Himalayan mountains in Southern Asian countries (Rana, 2003). The visualized results (Figure 7, 8) also display where the power is

centralized in particular countries and organizations, but influential actors vary from region to region. By using REDD+ projects and the networks, centralization and the patterns of partnership will be discussed and highlighted in the REDD+ projects, compared to financial network from the previous research (Kim et al., 2019).

5.1.1. Key countries

The key players at the project level are mostly USA-based organizations across the world, even though Norway and Japan have put forth the most financing (Table 5). Most of the organizations located in USA are NGOs (36%) and private actors (34%). USA-based NGOs and firms have been notably supporting REDD+ projects and have sponsored initial models of REDD+ projects, including avoided deforestation projects and the United States Initiative on Joint Implementation (USIJI) projects (Lile et al., 1998) under CDM, but USA government gave no funds to USIJI projects (Lile et al., 1998; Dixon, 2012). Especially, small and medium size enterprises have actively provided logistical, financial, and technical supports to develop forest-related projects (Dixon, 1998). With these accumulated experiences and its well-equipped location, USA-based organizations would have been likely to grow "network power" (Grewal, 2008). Therefore USA-based organizations have a comparative advantage and attractiveness as partners to build connections with developing countries (Gallemore and Munroe, 2013). USA-based actors have actively formed partnerships in REDD+ project networks (Table 5).

Among developing countries, Brazil received not only the majority of financial support, but also the greatest number of projects and the partnerships (Table 5). It seems to have a high capacity for the requirements

to proceed REDD+, such as the large scale of tropical forests. Another significant reason why Brazil is centered among developing countries in the network is the Amazon Fund established by Brazilian government. The Fund's main objective is to capture and attract many donors and projects for REDD+ projects in Brazil (Cenamo et al., 2009). The Amazon Fund has led voluntary donations from diverse stakeholders and the fund also has a specific guideline to encourage contribution and engagement of diverse stakeholders for the 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 in implementing REDD+ projects. The remarkable feature is that China is located outside of the network, not in the center, even with high centrality indexes (Figure 8B). This is to say that REDD+ projects conducted in China are more likely to build partnership with national organizations rather than with transnational partners. Only 13% of projects implemented in China (out of 31 projects) have partners from other countries, but other projects (87%) work with national stakeholders or organizations located in China. In contrast, most of the Indonesian projects (89% out of 35 projects) are based on transnational partnerships (Figure 8B).

5.1.2. Key organizations

In terms of organizations, seven out of top 10 most influential brokers (ordered by betweenness centrality) are NGOs (Appendix 5), even though the total number of actors by organization types is similar: public organizations (283), enterprises (296), and NGOs (279) (Table 3). Historically, NGOs had already conducted conservation development projects and customized them for REDD+ projects by using classic methods, including payment for ecosystem services (PES) and plantation establishments (Simonet et al., 2015). Since the beginning of REDD+, NGOs have heavily expanded their influence and engaged in project implementation and information flow (Gallemore and Munroe, 2013). Particularly, the Conservation International, the Nature Conservancy, and the Care International collaboratively established the Climate, Community, and Biodiversity Alliance (CCBA) in 2004 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+ (Borgatti and Everett, 2013), but also in implementation of the REDD+ projects with the most significant power over information flow (Appendix 5). It shows that NGOs take advantage of designing REDD+ projects by fitting existing projects to REDD+ standards without fundamental changes. Likewise, NGOs had rich experience in developing forest-related projects with conservation agendas before they started

REDD+ projects (Simonet et al., 2015). NGOs support REDD+ mechanism by getting fund and shaping projects in a comparative fashion (Brockhaus and Gregorio, 2014). Another critical feature is that many NGOs can empower local communities. For successful implementation of REDD+ projects, the engagement of local communities as major stakeholders is irresistible, but building official partnerships is sometimes hindered by licensing and incentive issues (Sills et al., 2014). For such reasons, project implementors look for NGOs that have the capacity to operate community-based projects as an alternative strategy without waiting for licenses.

As resulted in the research, project networks highlight that USA-based actors dominated REDD+ partnerships in the number and influence of network. Top influential actors in the networks are largely NGOs, among the types of stakeholders. The leading international organizations (WWF, IUCN, and World Bank) and global initiatives (FCPF and UN-REDD) in REDD+ financial networks do not actively work as partners in project networks (Table 4). Obviously, the results show that the partnership networks in REDD+ projects have a centralized structure, called “concentrated polycentricity”. Concentrated polycentric networks are spatially centralized, whereas polycentricity means a fragmented structure of the network 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 among diverse organization in the network provide many benefits (Bardhan, 2002): facilitating cross-level interactions by sharing information and cooperation (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 in order to encourage interaction between stakeholders.

Table 5. The key players of finance and project networks in the REDD mechanism.

Rank	Recipient Countries		Donor Countries		Organization	
	Amount of finance	Number of Partnership	Amount of finance	Number of Partnership	Amount of finance	Number of Partnership
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. The white blocks represent the results from this research and grey blocks present results from 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 fur Internationale Zusammenarbeit), TNC (The Nature Conservancy), UNDP (United Nations Development Programme), WWF (World Wide Fund for Nature), and WCS (Wildlife Conservation Society).

5.2. Coordination and collaboration

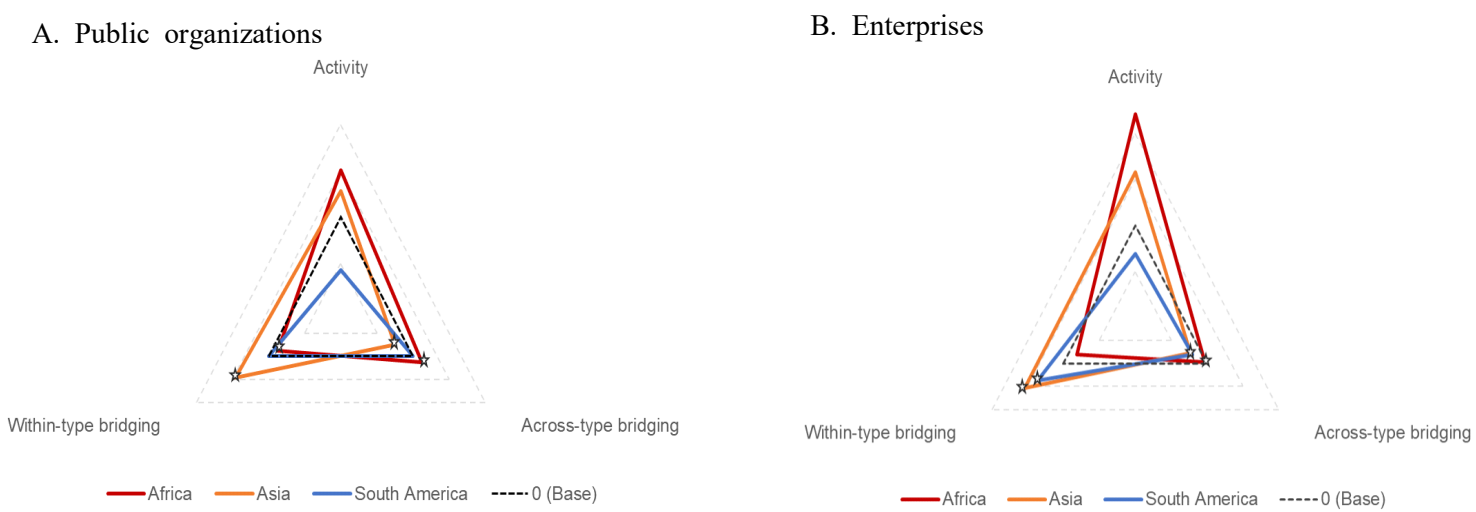
To answer Research Question 2:

RQ2. Which types of partnerships arise and what patterns do partnerships construct in REDD+ projects based on the characteristics of the types of organizations?

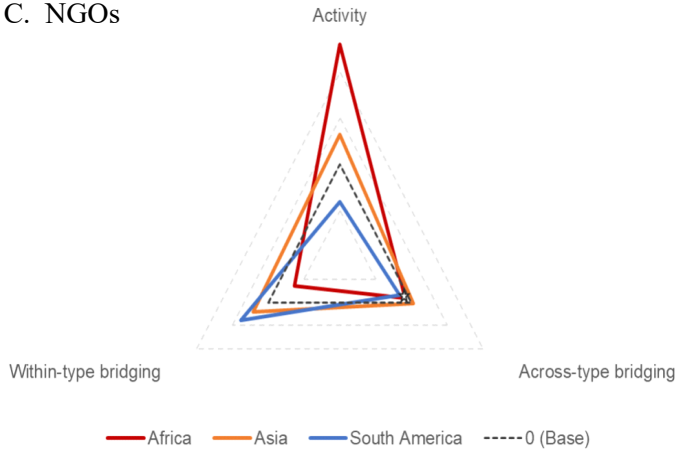
Partnerships with diverse stakeholders strengthen sustainable governance and capacity to resolve problems (McAllister and Taylor, 2015). It is necessary to navigate the diverse complexities of both coordination and cooperation when solving real world problems, such as climate and environment matters (Lubell, 2013). The partnership has diverse patterns according to purposes, characteristics, and organization type (Nita et al., 2016; Brockhaus and Gregorio, 2014; McAllister et al., 2015). To understand how organizations are involved in the REDD+ project partnership, we used ERGMs, using two key patterns, called configurations: within-type and across-type bridging configurations. Such configurations provide unbiased interpretations of complex and nested networks like the regression model. Within-type bridging can occur between same type actors 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). The statistical results (Table 4 and Figure 10) quantify configurations to explain the characteristics of partnerships in REDD+ project networks. Figure 10 is an illustrated version of Table 4 to visually compare and emphasize the differences in actors' roles by regions. Given ERGM modeling can only give a straightforward explanation, Figure 10 intuitionally tests whether the configuration (e.g., within-type and across-type bridging) exists more or less than expected alone (Wang et al., 2009; Wang et al., 2013; McAllister et al., 2015). The probability is interpreted as more chance or less chance according to the location whether the line is outside or inside 0 (base). For instance, Asian public actors (Figure 10A) are likely to form a within-type partnership and less likely to make partnerships across other types of organizations as the graph exists outside baseline at the left side (within-type bridging) and inside baseline at the right side (across-type bridging).

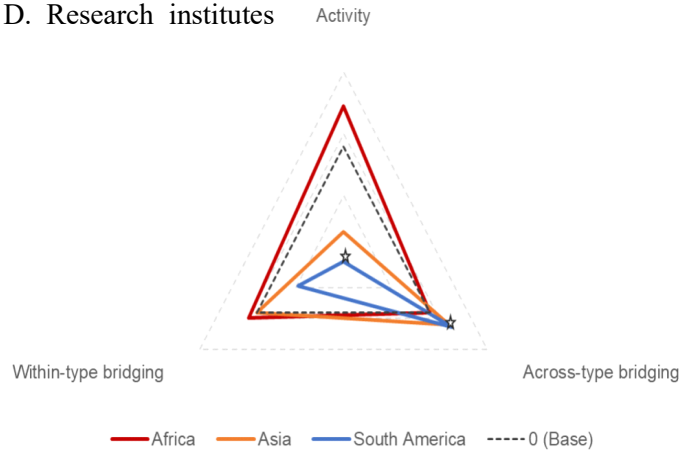
Figure 10. Configurations by Organization Types



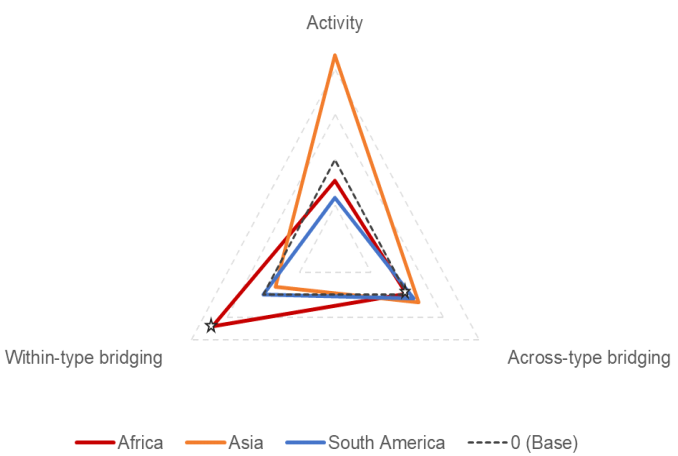
C. NGOs



D. Research institutes



E. Local communities



First of all, as most actors have less bonds across types in all regions, stakeholders may challenge sharing their know-how and knowledge, and access to them. However, public sectors in Africa (Figure 10A) and research institutes (Figure 10D) in Asia and South America show more than expected. International research institutions, such as CIFOR, have piled up global data about REDD+ and local research institutions 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, research organizations have a relatively small portion of all actors in the network (11%). In addition, public stakeholders in Africa show contrast patterns to the overall. Within-type bridging connections by public authorities in Africa are fewer, but across-type configurations are more than chance. African public sectors might consider across-type partnerships less risky or other African actors have the similar goals in alignment with public sectors when implementing REDD+ projects. In some way, public organizations in Africa are likely to build higher trust in others and work hard to build confidence as across-type bridging means the degree of trust. In much of Africa public sectors have taken the lead in forest restoration and especially REDD+ programs (Minang and Neufeldt, 2010). Governments have highly participated in the process and backed up REDD+ implementations (Asare et al., 2013). For example, the government of Kenya holds a leading position in REDD+ implementations. It works together

with diverse stakeholders such as the Kenya Forest Service (public organization), the Green Belt Movement (NGO), the Kenya Forestry Working Group (inclusive working group), and other public sectors. The cooperation surrounding the Kenyan government makes REDD+ projects less risky with strong cohesion (Minang and Neufeldt, 2010).

Second, the results highlight that organizations are more likely to form within-type partnerships (Figure 10A, 10B, 10C, and 10E). Exceptionally public organizations in Africa are likely to form less within-type partnerships. This is because stakeholders would try to avoid the potential challenge from across-type partnership, such as high transitional costs (McAllister and Taylor, 2015; McAllister et al., 2015). Another reason why there are more within-type partnerships than expected is that organizations already formed close-knit relationships with the same type 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 also show similar patterns (within-type bridging) as this research shows. Projects on nature conservation and environmental and climate action in EU follow within-type cooperation patterns (Nita et al., 2016). In the environmental projects, actors worked with the same type of organizations for avoiding conflicts of different interests and potential risks. In another case of urban development projects, most actors were also not likely to form bridging across other types because of risks

perceived by stakeholders (McAllister et al., 2015).

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

This research suggests an integrative venue where stakeholders with their own goals build trust and resolve conflicts. Although there was an international attempt to scale up partnerships, the REDD+ Partnership from 2010 to 2014 (Climate Initiatives Platform, n.d.), only national actors (75 countries) joined the network. Other stakeholders, including NGOs and enterprises, should participate in the new platform to share their interests and make trust relationships each other. Through communication, stakeholders can reduce the gap of expectations and establish confidence to meet technical and procedural requirement. For instance, the COPs of UNFCCC can be the ideal way by providing forums and activities for not only public parties, but NGOs, private actors, and local communities (Lesniewska, 2013).

5.3. Limitations of the REDD+ partnership network

The research delineates the key players and predominant patterns of partnership among stakeholders in REDD+ projects. The different approaches of social network analysis and statistical analysis (ERGMs) allow to interpret the structure of partnerships and why different actors build cooperation for REDD+ implementation. However, actors' motivations and partnership patterns are too complex to explain, and social network analysis is somewhat theoretic (La Viña and Lee, 2015). To understand such complexity of the REDD+ partnership better, qualitative research such as interviews or surveys should back up quantitative study. Moreover, it is highly limited to diagnose all of individual partnerships as the study covers global and regional scale networks (Sánchez-Algarra and Anguera, 2013).

There is some methodological limitation of this research. Depending on the ID-RECCO database, the scope of REDD+ projects in this study can be ambiguous concerning the scale, organization types, and activities. The dataset in this study would be moderately inclusive. Activities included in the research comprise of REDD, ARR, and IFM activities as long as projects have been conducted in developing countries and aimed at reducing emission from deforestation and forest degradation. However, some researchers only include REDD activities in REDD+ scheme by excluding ARR activities from the scope of REDD+ projects as ARR projects had been under a part of the

CDM (Simonet et al., 2015). In addition, the organizations were classified into five groups for intuitive interpretation and simplification of the coding system. The organizations can be analyzed with the multiple levels: international, national, and local. The diversification of organization types should be necessary for country-specific and in-depth research.

The statistical method, ERGM, only goes so far in straightforward explanation, given that the random theory can test whether the configuration exists more or less than expected alone (Wang et al., 2009; Wang et al., 2013; McAllister et al., 2015). In some parts of the results, the statistical degree of freedom may be too low to conclude significant as some organization types have few numbers, especially local communities (McAllister et al., 2015). Despite the limitations above, this study stands to kick in understanding REDD+ project networks and the whole picture of the REDD+ mechanism.

6. Conclusion

The REDD+ mechanism has been developed through global negotiation and participation from diverse stakeholders (Pistorius, 2012). Partnerships between stakeholders work as bridges for resources, knowledge, and information. REDD+ provides a unique stage for governance and collaboration of diverse stakeholders, including states, international organizations, NGOs, research institutes, and local communities (Gallemore and Munroe, 2013). Our research delineates the key players and predominant patterns of partnership among stakeholders in REDD+ projects. Global and regional network analysis (Figure 7 and 8) reveals the centralization around core actors and actors' positions in networks for resource exchange, information flow, and partnerships. The different approaches of social network analysis and statistical analysis (ERGMs) allow us to interpret the structure of partnerships for REDD+ implementation. ERGMs (Table 4 and Figure 10) configure inter and cross-sectional networks, highlighting within-type bridging. However, centralization and tendency toward within-type collaboration can limit participation by multiple stakeholders and may cause brokers to take advantage of incentives. This trend may challenge project proponents to communicate and cooperate with other partners. Nita et al. (2016) suggest that cross-sectoral partnerships have the potential to narrow the space between

stakeholders. Proponents need to consider cross-sectoral partnerships for improving efficiency and effectiveness in governance.

Unfortunately, this research has some limitations. Actors' motivations and partnership patterns are too complex to explain, and social network analysis is somewhat theoretic (La Viña and Lee, 2015). To understand such complexity of the REDD+ partnership better, qualitative research such as interviews or surveys is necessary for supplementing quantitative study. Moreover, the statistical method, ERGM, only goes so far in straightforward explanation, given that the random theory can test whether the configuration exists more or less than expected alone (Wang et al., 2009; Wang et al., 2013; McAllister et al., 2015).

Despite the limitations above, 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 analysis and for predicting partnership performance, constraints, and diffusion of information (Borgatti and Everett, 2013). By analyzing stakeholders, the results can be used as a basis for identifying country or institution's ability to carry on. International and national policymakers would refer to the results to benchmark partnership potential and to formulate policies for REDD+ project implementation as this research gives specific suggestions for the network management, especially the way to link stakeholders to promote partnerships, cooperation, and resiliency.

Understanding network patterns and structures can be the first step as the theoretical and analytical tools for future studies on natural resource management (Lubell et al., 2014). It is expected that future research and projects will benefit from our results, which translate a comprehensive picture of REDD+ architecture.

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Appendix 1. Data Source

Name of the source	Link to Internet page
Forest Carbon Portal, by Forest Trends	http://www.forestcarbonportal.com/project/
REDD+ database, by the Institute for Global Environmental Strategy (IGES)	http://redd-database.iges.or.jp/redd/
The REDD country database (Collaborative resource for REDD Readiness)	http://www.theredddesk.org/countries
Global database on REDD+ and other forest carbon projects, by the Center for International Forestry Research (CIFOR)	http://www.forestclimatechange.org/redd-map/
Eco2data (limited access)	http://eco2data.com/(last available as of June 2015)
Code REDD: REDD projects	http://www.coderedd.org/
Carbon Catalogue	http://www.carboncatalog.org/
Voluntary REDD+ Database, by the REDD+ Partnership	http://www.reddplusdatabase.org/#introduction
REDD X- Tracking Forest Finance, by Forest Trends	http://reddx.forest-trends.org/
Agriculture, Forestry, Land use projects, Verified Carbon Standard (VCS) database	http://www.vcsprojectdatabase.org/
The Climate, Community and Biodiversity Alliance (CCBA) database	http://www.climate-standards.org/category/projects/

Plan Vivo database	http://www.planvivo.org/projects/registeredprojects/
UNFCCC CDM Registry	http://cdm.unfccc.int/Registry/index.html
SCS global services (and other verifiers)	http://www.scsglobalservices.com/verified-carbon-offset-projects
"Community Participation and Benefits in REDD+: A Review of Initial Outcomes and Lessons", by Lawlor et al. 2013	Lawlor, K.; Madeira, E. M.; Blockhus, J. & Ganz, D. J. (2013), 'Community Participation and Benefits in REDD+: A Review of Initial Outcomes and Lessons', Forests 4(2), 296--318
Bringing forest carbon to market, by Chenost et al. 2010	Chenost, C.; Gardette, Y.; Demenois, J.; Grondard, N.; Perrier, M. & Wemaere, M. (2010), Bringing forest carbon projects to the market, UNEP
« REDD+ à l'échelle projet - Guide d'évaluation et de développement », by ONF International	Calmel, M.; Martinet, A. & Grondard, N. (2011), 'REDD+ à l'échelle projet. Guide d'évaluation et de développement.', Technical report, ONFI
REDD monitor: news	http://www.redd-monitor.org/
Forest Carbon Asia: news	http://www.forestcarbonasia.org/
APX VCS Registry	https://vcsregistry2.apx.com/myModule/rpt/myrpt.asp?r=206
Markit Environmental Registry	http://mer.markit.com/br-reg/public/index.jsp?entity=project&sort=project_name&dir=ASC&start=0&acronym=&limit=15&name=&standardId=

Appendix 2. 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 Bridging	actor-project	-3.51	-1.88	0.14	-1.89	0.92	-1.95
	actor-project-actor	-3.47	-1.28	0.15	-1.29	0.85	-1.29
Activity	Public organization	-1.94	-1.89	0.1	-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	-1.9	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	-1.28	1.71	-1.3
	Research institute	-1.63	-1.29	2.28	-1.3	3.32	-1.3
	local community	-3.15	-1.3	0.5	-1.35	2.37	-1.29
Within-type bridging	Public organization	-1.26	-1.3	3.51	-1.27	-	-
	Enterprise	2.45	-1.28	0.07	-1.31	3.97	-1.29
	NGO	6	-1.27	0.32	-1.27	2.07	-1.3
	Research institute	0.03	-1.27	-	-	3.65	-1.29
	local community	-4.22	-1.35	0.32	-1.59	-	-

Appendix 3. Centrality of Supporting Countries in the Global Partnership Network

Rank	Country	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	USA	166	0.589	0.472	0.393
2	Switzerland	51	0.153	0.389	0.010
3	UK	44	0.104	0.362	0.008
4	Germany	33	0.063	0.342	0.004
5	France	27	0.049	0.344	0.012
6	Spain	22	0.033	0.344	0.002
7	Italy	19	0.022	0.328	0.003
8	Canada	18	0.021	0.335	0.004
9	Netherlands	12	0.019	0.313	0.001
10	Japan	11	0.013	0.305	0.002
11	Luxemburg	14	0.010	0.324	0.000
12	Belgium	6	0.010	0.262	0.000
13	South Korea	5	0.006	0.271	0.000
14	Singapore	8	0.004	0.287	0.002
15	Austria	3	0.004	0.279	0.000
16	Australia	7	0.002	0.297	0.002
17	Norway	4	0.002	0.268	0.001
18	Ireland	5	0.002	0.306	0.001
19	Sweden	3	0.000	0.272	0.000
20	Hongkong	2	0.000	0.288	0.000

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

Appendix 4. Centrality of Hosting Countries in the Global Partnership Network

Rank	Country	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	Brazil	58	0.130	0.335	0.022
2	China	32	0.091	0.301	0.003
3	Peru	28	0.067	0.320	0.003
4	Colombia	37	0.061	0.324	0.919
5	Indonesia	27	0.037	0.309	0.005
6	Mexico	17	0.031	0.310	0.002
7	India	16	0.030	0.298	0.002
8	Uruguay	11	0.028	0.244	0.000
9	Kenya	20	0.022	0.347	0.017
10	South Africa	8	0.021	0.243	0.000
11	Tanzania	11	0.019	0.293	0.013
12	Chile	9	0.018	0.296	0.003
13	Ghana	8	0.016	0.290	0.002
14	Congo	13	0.015	0.282	0.001
15	Bolivia	5	0.014	0.260	0.000
16	Uganda	17	0.013	0.307	0.005
17	Solomon Islands	3	0.010	0.279	0.000
18	Senegal	6	0.008	0.244	0.000
19	Cameroon	5	0.007	0.292	0.000
20	Fiji	4	0.007	0.287	0.003

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

Appendix 5. Centrality of Individual Organizations in the Global Partnership Network

Rank	Name	Country	Type	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	Conservation International (CI)	USA	NGO	14	0.110	0.341	0.000
2	Terra Global Capital (TGC)	USA	NGO	16	0.097	0.309	0.306
3	The Nature Conservancy (TNC)	USA	NGO	18	0.097	0.303	0.000
4	WWF	Switzerland	NGO	20	0.079	0.312	0.000
5	United States Agency for International Development (USAID)	USA	Public organization	14	0.037	0.290	0.022
6	GiZ (Deutsche Gesellschaft fur Internationale Zusammenarbeit)	Germany	Public organization	8	0.037	0.294	0.000
7	Institute for Conservation and Sustainable Development of Amazonas - IDESAM	Brazil	NGO	2	0.034	0.228	0.000
8	Wildlife Conservation Society (WCS)	USA	NGO	13	0.034	0.283	0.000
9	TerraCarbon LLC	USA	Enterprise	6	0.030	0.268	0.000
10	CARE	Switzerland	NGO	5	0.030	0.286	0.005
11	ONF International	France	Public organization	7	0.029	0.283	0.000

12	Flora and Fauna International (FFI)	UK	NGO	12	0.029	0.278	0.003
13	South Pole Carbon (South Pole Carbon)	Switzerland	Enterprise	10	0.029	0.265	0.001
14	Kingdom of Spain - Ministry of Agriculture, Food and Environment & Ministry of Economy and Competitiveness	Spain	Public organization	14	0.028	0.249	0.000
15	Centro de Investigación Carbono y Bosques (C&B)	Colombia	Research institute	7	0.028	0.260	0.286
16	WCS (Wildlife Conservation Society)	USA	NGO	4	0.028	0.295	0.000
17	Oxford University	UK	Research institute	2	0.022	0.182	0.000
18	Sokoine University of Agriculture	Tanzania	Research institute	5	0.020	0.273	0.002
19	ecoPartners (Ecological Carbon Offset Partners, LLC)	USA	Enterprise	9	0.019	0.238	0.382
20	World Education Inc.	USA	NGO	3	0.017	0.278	0.000

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

Appendix 6. Centrality of Countries in the African Network

Rank	Country	Role of Country	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	USA	Supporting country	65	0.610	0.536	0.216
2	UK	Supporting country	22	0.220	0.422	0.025
3	Switzerland	Supporting country	15	0.111	0.388	0.023
4	Uganda	Hosting country	16	0.089	0.386	0.044
5	Kenya	Hosting country	17	0.082	0.403	0.100
6	South Africa	Hosting country	7	0.072	0.260	0.000
7	Congo	Hosting country	13	0.056	0.327	0.005
8	Ghana	Hosting country	7	0.054	0.333	0.006
9	France	Supporting country	11	0.048	0.373	0.003
10	Germany	Supporting country	9	0.043	0.355	0.003

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

Appendix 7. Centrality of Individual Organizations in the African Network

Rank	Name	Country	Type	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	Wildlife Conservation Society (WCS)	USA	NGO	10	0.087	0.266	0.001
2	CARE	Switzerland	NGO	4	0.085	0.288	0.022
3	Sokoine University of Agriculture	Tanzania	Research institute	5	0.081	0.286	0.002
4	WWF	Switzerland	NGO	7	0.072	0.238	0.001
5	UNDP (United Nations Development Programme)	USA	Public organization	2	0.071	0.269	0.018
6	Terra Global Capital (TGC)	USA	NGO	5	0.062	0.277	0.005
7	Green Belt Movement (GBM)	Kenya	NGO	2	0.062	0.241	0.000
8	World Vision	UK	NGO	3	0.051	0.235	0.000
9	Flora and Fauna International (FFI)	USA	NGO	3	0.047	0.226	0.000
10	Kenya Forest Service	Kenya	Public organization	4	0.046	0.235	0.000

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

Appendix 8. Centrality of Countries in the Asian Network

Rank	Country	Role of Country	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	USA	Supporting country	33	0.275	0.498	0.492
2	China	Hosting country	30	0.250	0.323	0.363
3	Indonesia	Hosting country	27	0.225	0.206	0.381
4	Switzerland	Supporting country	14	0.117	0.163	0.408
5	India	Hosting country	15	0.125	0.114	0.332
6	Germany	Supporting country	15	0.125	0.103	0.369
7	Laos	Hosting country	6	0.050	0.046	0.330
8	Netherlands	Supporting country	6	0.050	0.034	0.330
9	UK	Supporting country	8	0.067	0.034	0.324
10	Nepal	Hosting country	4	0.033	0.025	0.253

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

Appendix 9. Centrality of Individual Organizations in the Asian Network

Rank	Name	Country	Type	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	World Education Inc.	USA	NGO	3	0.249	0.272	0.007
2	Forestry Administration of Cambodia	Cambodia	Public organization	2	0.190	0.254	0.071
3	GiZ (Deutsche Gesellschaft fur Internationale Zusammenarbeit)	Germany	Public organization	6	0.189	0.225	0.000
4	The Nature Conservancy (TNC)	USA	NGO	4	0.180	0.272	0.001
5	Flora and Fauna International (FFI)	UK	NGO	8	0.134	0.191	0.000
6	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	Germany	Public organization	4	0.132	0.250	0.000
7	Winrock International	USA	NGO	3	0.102	0.260	0.002
8	WWF	Switzerland	NGO	10	0.088	0.235	0.001
9	Netherlands Development Organisation (SNV)	Netherlands	Public organization	4	0.087	0.234	0.001
10	Terra Global Capital (TGC)	USA	Enterprise	4	0.075	0.162	0.000

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

Appendix 10. Centrality of Countries in the South American Network

Rank	Country	Role of Country	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	USA	Supporting country	66	0.500	0.462	0.344
2	Brazil	Hosting country	52	0.266	0.361	0.018
3	Peru	Hosting country	27	0.162	0.349	0.003
4	Colombia	Hosting country	35	0.145	0.353	0.939
5	Switzerland	Supporting country	21	0.125	0.389	0.007
6	Mexico	Hosting country	16	0.072	0.318	0.002
7	UK	Supporting country	14	0.069	0.339	0.004
8	Uruguay	Hosting country	11	0.062	0.261	0.000
9	France	Supporting country	11	0.042	0.340	0.011
10	Germany	Supporting country	8	0.041	0.317	0.002

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

Appendix 11. Centrality of Individual Organizations in the South American Network

Rank	Name	Country	Type	Degree	Betweenness Centrality	Closeness Centrality	Eigenvector Centrality
1	Conservation International (CI)	USA	NGO	6	0.111	0.317	0.000
2	South Pole Carbon	Switzerland	Enterprise	10	0.106	0.320	0.001
3	Centro de Investigación Carbono y Bosques (C&B)	Colombia	research institute	7	0.099	0.296	0.288
4	The Nature Conservancy (TNC)	USA	NGO	11	0.040	0.262	0.000
5	CORNARE	Colombia	Public organization	2	0.036	0.234	0.001
6	Asociación para la Investigación y Desarrollo Integral (AIDER)	Peru	NGO	7	0.033	0.245	0.000
7	TerraCarbon LLC	USA	Enterprise	4	0.032	0.192	0.000
8	ONF International	France	Public organization	5	0.023	0.218	0.000
9	Terra Global Capital (TGC)	USA	Enterprise	7	0.016	0.236	0.288
10	United States Agency for International Development (USAID)	USA	Public organization	7	0.012	0.231	0.021

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

Abstract in Korean

국 문 초 록

REDD+ 사업의 글로벌 파트너십 네트워크 분석

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기후변화 완화 수단으로 개도국에서 산림전용 및 산림황폐화로 인한 온실가스 배출 감축 활동(REDD+)이 진행되고 있다. 이해관계자들 간 파트너십은 REDD+ 프로젝트를 성공적이고 지속가능하게 이행하는 데 있어서 중요한 기준이 되고 있다. 따라서, 본 연구는 중심성 지수, 블록모델링, 지수무작위그래프모형(ERGM)을 활용하여 REDD+ 프로젝트 수행단계에서 형성되는 파트너십의 중심성, 패턴, 구조를 분석하였다.

57개국에서 시행된 480개 REDD+ 프로젝트 정보를 수집하여 분석한 결과, 전체적으로 미국, 브라질, 중국 기반 기관이 REDD+ 네트워크를 강하게 통제하고 있었으며 이들을 중심으로 집중된 다극성 네트워크(concentrated polycentric network)구조가 만들어졌다. 통계적 네트워크 모델링을 활용하여 분석한 결과 다른 유형의 기관이 서로 파트너십을 형성할 가능성은 전반적으로 낮지만, 동일한 유형의 기관과의

협력 경향성은 다소 높게 나타났다. 예외로, 연구 기관은 높은 기술 역량을 바탕으로 다양한 유형의 기관과 파트너십을 형성했다.

본 연구는 REDD+ 메커니즘의 전체적인 구조와 핵심 주체를 종합적으로 이해하는 데 기여한다. 본 연구를 기반으로 국가별 타겟팅(targeting) 분석, 지리적 한계 파악, 파트너십 형성 예측 등의 연구를 추진할 수 있을 것이다. 또한, 본 연구결과는 이해관계자 분석을 통해 개별 국가 또는 기관의 사업 이행능력을 파악하고 REDD+ 프로젝트 설계를 위한 기초 자료로 활용할 수 있을 것으로 기대한다.

주요어: REDD+, 파트너십, 소셜네트워크분석, 거버넌스, ERGM, 기후변화

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