



Beyond the community in participatory forest management: A governance network perspective

Friedman, Rachel; Guerrero, R S; McAllister, R R J; Rhodes, Jonathan; Santika, Truly; Budiharta, Sugeng; Indrawan, Tito P.; Hutabarat, Joseph A.; Kusworo, Ahmad; Yogaswara, H; Meijaard, Erik; St John, Freya A. V.; Struebig, Matthew J.; Wilson, Kerrie A

Land Use Policy

DOI:

[10.1016/j.landusepol.2020.104738](https://doi.org/10.1016/j.landusepol.2020.104738)

Published: 01/09/2020

Peer reviewed version

[Cyswllt i'r cyhoeddiad / Link to publication](#)

Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA):

Friedman, R., Guerrero, R. S., McAllister, R. R. J., Rhodes, J., Santika, T., Budiharta, S., Indrawan, T. P., Hutabarat, J. A., Kusworo, A., Yogaswara, H., Meijaard, E., St John, F. A. V., Struebig, M. J., & Wilson, K. A. (2020). Beyond the community in participatory forest management: A governance network perspective. *Land Use Policy*, 97, Article 104738. <https://doi.org/10.1016/j.landusepol.2020.104738>

Hawliau Cyffredinol / General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Beyond the Community in Participatory Forest Management: A Governance Network Perspective

Authors:

Rachel S. Friedman ^{1,2,3*}, Angela M. Guerrero ^{1,2}, Ryan R. J. McAllister ⁴, Jonathan R. Rhodes ^{2,3}, Truly Santika ^{1,2,5,6}, Sugeng Budiharta ^{2,7}, Tito P. Indrawan ⁸, Joseph A. Hutabarat ⁸, Ahmad Kusworo ^{8,9}, Herry Yogaswara ¹⁰, Erik Meijaard ^{2,5}, Freya A.V. St. John ¹¹, Matthew J. Struebig ⁶, & Kerrie A. Wilson ^{1,2,12}

Affiliations

- 1 School of Biological Sciences, University of Queensland, Brisbane, Australia
- 2 ARC Centre of Excellence for Environmental Decisions, University of Queensland, Brisbane, Australia
- 3 School of Earth and Environmental Sciences, University of Queensland, Australia
- 4 CSIRO GPO Box 2583, Brisbane QLD Australia
- 5 Borneo Futures, Bandar Seri Begawan, Brunei Darussalam
- 6 Durrell Institute of Conservation and Ecology (DICE), School of Anthropology and Conservation, University of Kent, Canterbury, UK
- 7 Purwodadi Botanic Garden, Indonesian Institute of Sciences (LIPI), Pasuruan, Indonesia
- 8 Fauna & Flora International - Indonesia Programme, Jakarta, Indonesia
- 9 The Nature Conservancy – Indonesia Programme, Kebayoran Baru, Jakarta, Indonesia
- 10 Division of Human Ecology, Research Center for Population, Indonesian Institute of Sciences, Indonesia
- 11 School of Natural Sciences, Bangor University, Bangor University, UK
- 12 Institute for Future Environments, Queensland University of Technology, Brisbane, Australia

* *Corresponding author:* Rachel Friedman

Address: Steele Building #3, School of Earth and Environmental Sciences, University of Queensland, Saint Lucia, Queensland, Australia 4072

Email: r.friedman@uq.edu.au

The authors have no competing interests to declare

TPI and JAH are employed by an organisation included in the analysis, but did not take part in the analysis, and all references to organisation and interviewee identities were removed.

Abstract

Governance of the environment and natural resources involves interests of multiple stakeholders at different scales. In community-based forest management, organisations outside of communities play important roles in achieving multiple social and ecological objectives. How and when these organisations play a role in the community-based forest management process remains a key question. We applied social network analysis to a case study in Indonesian Borneo to better understand the evolution of interactions between organisational actors, and with communities. NGOs featured most prominently in initiating the permit process, implementing management, and providing other support activities, while also being well-connected to donors and government actors. The network configurations indicated significant cooperation among organisations when initiating the community forest process, while bridging between village and organisational levels characterised all stages of the community forest process. While community-based forest management often evokes images of grassroots efforts and broad local capacity to manage forests, reality shows a more dynamic and heterogeneous picture and broader involvement of different actor types and motivations in Indonesia. These findings can be applied to other countries implementing and expanding their decentralised forest policies.

Keywords: social network analysis; community-based forest management; Indonesia; decentralised governance; forest policy

1. Introduction

1.1 Community-based forest management

Forest conservation increasingly strives for win-wins, trying to both protect nature and support human well-being (McKinnon et al., 2016). This reflects how forested landscapes around the world not only sustain considerable biodiversity, contribute to clean water supply, and regulate the climate, but also form the basis of the livelihoods for millions of people (Gilmour, 2016). Decentralised natural resources governance models, such as community-based forest management, have been promoted as a means of further promoting this multi-functionality by achieving both local livelihood and well-being benefits and biodiversity conservation or sustainable natural resources management (Agrawal et al., 2008; Calfucura, 2018).

While the definition of community-based forest management (CFM) is very broad and encompasses a variety of land tenure systems, governance models, and institutional arrangements, it is generally characterised by links between environment and development, engagement of local communities, and devolved control over natural resources (Brooks et al., 2012). In a review of community forestry over the past forty years, Gilmour (2016) used a broad definition of CFM as “initiatives, sciences, policies, institutions and processes that are intended to increase the role of local people in governing and managing forest resources”. Here we focus on the dominant form of CFM in Asia: formalised government-led initiatives that decentralise forest governance to a local level. Under such schemes, ownership of forested land is maintained by the State, but administrative functions and management responsibilities are devolved to communities (Adger et al., 2006; Fisher, 1999; Gilmour, 2016). Thus, while the origins and discourse of CFM suggest grassroots efforts (Marshall, 2008), for this genre of CFM it is critical to consider the relationships with, and influences of, actors beyond communities.

Interactions between different stakeholders have important implications for addressing the inevitably complex social and ecological issues associated with forest conservation (Bell and Morrison, 2015). The changing interactions between different actors, and the learning that happens through these

interactions, are considered important for moving to a community-based model of forest management and yet are rarely addressed in study or practice (Gilmour, 2016). Previous case studies have outlined different stages that community-based forest management might go through, and the points at which external actors would be active, including a start-up phase, building capacity for forest protection and management, and moving toward long-term self-management (Gilmour, 2016). As such, considering the dynamic nature of stakeholder interactions, developing a better understanding of the ways in which actors outside the community interact, and how those relationships develop and change over time, can help understanding the governance network and clarify what underpins the processes and long-term success of community-based natural resources management efforts (Alexander et al., 2016; Calfucura, 2018).

Empirical analysis of influences and relationships within complex networks of stakeholders is considered an important area of research for CFM (Gallemore et al., 2015; Santika et al., 2017). Other studies have suggested that the ability of community members to liaise with actors outside village bounds is key to achieving successful forest management by communities (Baynes et al., 2015). Social network analysis (SNA) – which models interactions between stakeholders, permitting analysis of observed network structures and their effects on actor- or system-level outcomes (Borgatti et al., 2009) – provides one method by which to explore such interactions and associated questions around natural resources governance. Network analysis has demonstrated utility in understanding the relationships between heterogeneous groups of actors involved in management and the underlying social processes, such as collaboration, information sharing, building trust, and social capital (Borg et al., 2015; Salpeteur et al., 2017). However, few studies that focus explicitly on formalised CFM employ social network analysis to examine interactions between stakeholders or the evolution of the network structure.

There are, however, social network analysis studies on community-based natural resources management more generally, which concentrate on the local level or on locally-driven models (Barnes-Mauthe et al., 2016; Bodin and Crona, 2008; Cohen et al., 2012). For forests, Garcia-Amado, et al. (2012) looked at local level decision-making and collective action in a case study of the *Ejido* model of CFM in Mexico, as well as the progression of membership in coffee associations over time. A few studies have also broadened the network to include both local people and external organisations. For example, Schusser (2013) used network principles to explore relationships like power dynamics between individual actors in multi-level (individuals and organisations) community forestry networks. Lauber, et al. (2008) described stakeholders (local and external) involved in community forestry projects in the United States, identifying stages where different types of stakeholders might be most important. Garcia-Amado, et al. (2012), Schusser (2013), and Lauber, et al. (2008) all focused on locally derived initiatives, which set a different context for how these relationships develop compared to initiatives formalised through government policy.

Considering the existing scholarship, there is considerable opportunity to improve our understanding of the dynamic nature of CFM networks, particularly in the context of State-driven decentralisation programmes. One gap in this research area is how the relationships among external organisations and local communities evolve through the development of CFM programmes, and what social process may be at work during different stages. Our study focuses on interactions between external organisations and their engagement in local communities at different stages in the CFM process. It examines structural patterns in the network, and specific attributes of actors, to draw conclusions about how social capital changes over time in CFM networks. To do so, we first discuss literature on the role of social capital in CFM, the significance of characteristics of the actors involved, and how network structure can reflect social processes in community forest governance.

1.2. Conceptual Framework

Social network analysis has been used as a means of assessing natural resources policy instruments like CFM, and to link social capital and governance concepts (Górriz-Mifsud et al., 2016). Structural configurations in networks represent patterns of interactions between actors that are associated with underlying social processes considered central to successful natural resources governance (Barnes et al., 2017; Bodin et al., 2019). Here we focus on social capital as a key component for community-based forest management, and consider how closed and open configurations of interactions between different actors can be indications of these underlying social processes (Figure 1, Table 1).

‘Bonding social capital’ – which relates to interconnectedness and overlapping relationships (Berardo, 2014; Ingold, 2017; Pretty, 2003) – can build trust and shared norms among different organisational actors. In network terms, closed structures - such as triangles of three actors (TriangleXBX, Table 1) - are employed as proxies for bonding social capital and can indicate cooperation (Berardo and Scholz, 2010; Bodin et al., 2016; Guerrero et al., 2015; Robins et al., 2011). Cooperation reflects how well and how much actors work together, and thus can be important for successful community-based conservation and natural resources management (Berardo, 2014; Calfucura, 2018; Pretty, 2003). Because each actor interacts – communicates, collaborates, etc. – with one another, this configuration provides a redundancy of ties, can permit close scrutiny of actions, and therefore serve to enhance accountability of actors carrying out their roles and responsibilities.

Conversely, ‘bridging social capital’ links disparate groups and extends one’s sphere of influence beyond immediate neighbors (Baynes et al., 2015; Berardo, 2014). This can enable coordination across different locations or scales (Alexander et al., 2015; Guerrero et al., 2015), bring together complementary expertise (Cash et al., 2006), aid transmission of knowledge and innovation (Ingold, 2017), and indicate links between communities and the “outside world” (Baynes et al., 2015; Calfucura, 2018; McAllister et al., 2014). Open structures - such as star configurations where one actor connects groups of different actors (multi-level stars in Table 1) - serve as indicators of bridging social capital between levels of a network (Barnes et al., 2017; Berardo, 2014). For instance, bridging structures can be found in environmental governance networks, where a core group facilitates coordination of activities by a broader set of actors or transmits information from one level to another (Barnes et al., 2017; Berardo, 2014; Lubell et al., 2017).

The literature on community-based forest management (CFM) highlights how different types of stakeholders are involved in governance of forest resources, from state actors and donors to non-governmental organisations and private corporate entities (Leisher et al., 2016; Macura et al., 2015; Tacconi, 2011). These types of external actors may have different strengths within the CFM process, such as long-standing relationships with villages or influence at higher levels of government. Bridging configurations between different types of organisations may be able to facilitate dissemination of information through a governance landscape and across disparate groups (Cash et al., 2006; McAllister et al., 2014; Pahl-Wostl, 2009). Objectives of different actors are also a critical consideration, as they influence what is considered the ideal outcome of community-based forest management. While at first devised to combat forest degradation and loss, CFM initiatives now also strive to address a range of environmental as well as social, economic, and political goals (Gilmour, 2016). Strong social networks that bridge interests of different stakeholders therefore may make CFM more likely to achieve its multiple stated goals (Kellert et al., 2000).

The characteristics of actors that interact with each other are a critical piece of the social capital puzzle. Configurations supporting bonding social capital and cooperation between actors with different attributes can contribute to achieving diverse goals (Adger, 2003; Baral, 2012; Barnes et al.,

2017; Berardo, 2014; Henry and Vollan, 2014; Robins et al., 2011). As such, a closed configuration that has fewer matches of organisation type attribute (Figure 1), can be seen as serving to foster cooperation between different organisations. While bonding configurations between homogeneous organisations may make actions easier or more efficient, they may also restrict the permeation of novel ideas or information (Berardo and Scholz, 2010). For instance, some studies have shown that information exchange often occurs within clusters of organisations of the same type (Moeliono et al., 2013), yet information exchange among a broad set of stakeholders in natural resources management and multi-level governance can lead to integration of diverse knowledge types and innovative solutions to resource governance challenges (Cash et al., 2006; Pahl-Wostl, 2009). Bonding structures between actors with different primary objectives can also be considered a precursor to resolving conflicts in natural resources governance by building close relationships (McAllister et al., 2015).

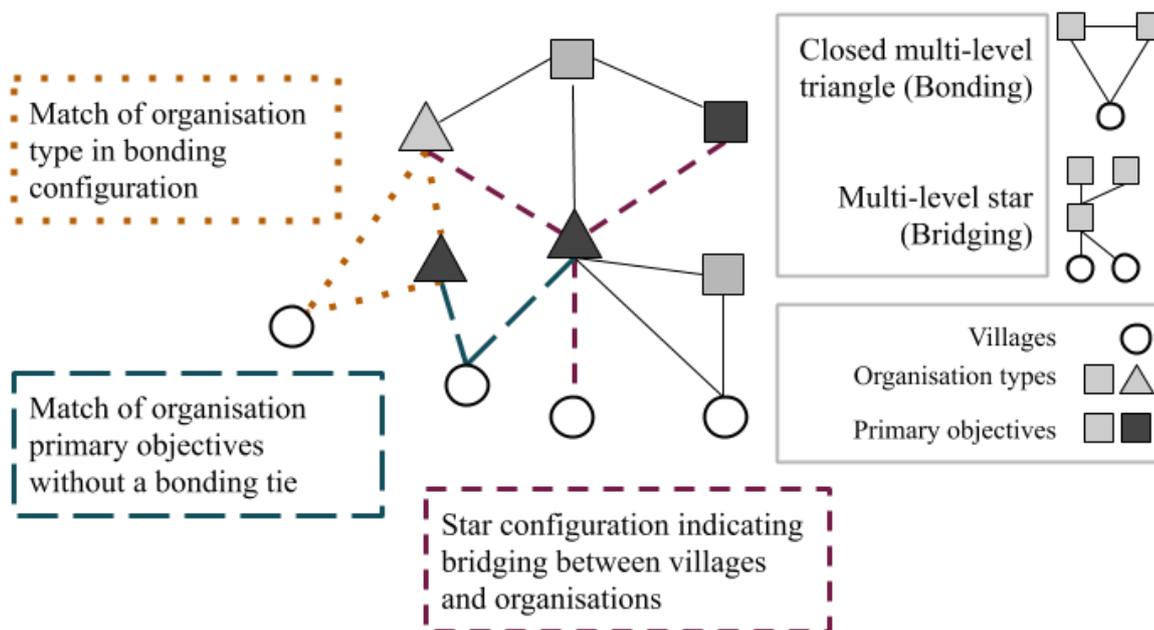
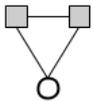
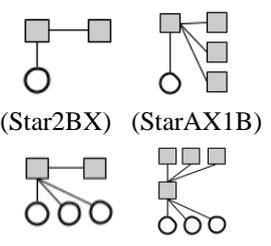
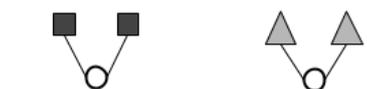


Figure 1. Configurations associated with social processes of interest for community-based forest management.

Based on this conceptual foundation, we anticipate that the prevalence of different network structures would change based on the needs during different stages of a community forest. During early development of community forests, we would expect to see indications of bonding configurations, as actors must build trust and determine their shared objectives. We also expect fewer matches of organisation types and objectives to accommodate the variety of expertise required as forest management plans are established and goals set during this time. In later stages of community forest development, we might expect to see the persistence of heterogeneous organisational objectives (interactions between different attributes) to support achieving multiple objectives, but fewer bonding structures, which become less important after trust and common ground have already been established. At these later stages, bridging configurations would be important for broadening a community's network to reach external actors that could be sources of information, training, and other support. This mix of bonding and bridging social capital would align with suggestions from previous studies on natural resources management, reflecting the multiple social processes at play and an increased ability to adapt to changing needs (e.g. Bodin et al., 2006; Levy and Lubell, 2018; Newman and Dale, 2005).

Table 1. Summary of conceptual significance from the literature associated with the different network configurations. Grey shapes (squares and triangles) indicate organisational nodes, and white circles indicate villages. Linked triangles show a mismatch in type of organisation, and linked squares show a mismatch in primary objective.

Social Capital	Network Configuration (MPNet name)	Conceptual Significance
Bonding	Closed multi-level triangle –  (TriangleXBX)	Multi-level closed triangles can be used as indicators of cooperation in exponential random graph models (ERGMs; Bodin et al., 2016; Guerrero et al., 2015). In this case, triangle configurations show organisations active during specific stages in the same villages and interacting with each other.
Bridging	Multi-level stars –  (Star2BX) (StarAX1B) (StarAB1X) (StarAXAB)	Multi-level stars serve as indicators of bridging social capital. Such bridging or brokerage positions connect levels of a network, extending groups beyond their closest neighbors (Barnes et al., 2017; Ernstson et al., 2010). These can enable coordination across localities or scales* (Alexander et al., 2015; Angst et al., 2018; Vignola et al., 2013), and denote strategic links between communities and powerful external actors (Calfucura, 2018; McAllister et al., 2014).
Qualifiers of Bonding and Bridging	Matching attributes –  (primary objective) (organisation type)	Matches – organisations with the same attributes – indicate homogeneity of expertise and motivation. In conjunction with bonding or bridging configurations, fewer matched attributes can signal communication, information dissemination, and learning across groups (Barnes et al., 2016; Cash et al., 2006).

* The bridging configuration L3XBX was also included in the models, as an indication of coordination across localities, and to help convergence. Inclusion did not yield significant results; the full model results are presented in Table S1.

We applied network analytical methods in the context of formalised community-based forest management, in order to understand how the network of external organisations develops. Considering the current drive for CFM schemes and the decades of expansion in Southeast Asia, understanding how organisational actors are involved and interact throughout this process is timely for informing ongoing development and implementation. Drawing on semi-structured interviews and network data (e.g. Lauber et al., 2008; McAllister et al., 2014; Schusser, 2013), we examine the following two related questions through a case study of community-based forest management in Indonesian Borneo:

- 1) How do the relationships among external organisations and local communities change during the evolution of a CFM programme?
- 2) What does the evolution of network structure across the development of CFM programme tell us about the social processes that are important for the management of forest resources?

2. Methods

2.1. Case study of social forestry in Indonesia

Indonesia presents an insightful case through which to study CFM networks. It is of international significance as a biodiversity hotspot experiencing rapid deforestation and agriculture expansion, as well as a contemporary model of the implications of decentralization reforms for forest management. Indonesia began decentralising much political authority from state to province, district, and village levels after the end of the country's previous government in 1998, when the *reformasi* process sought to balance development and conservation (Jewitt et al., 2014; Resosudarmo et al., 2012). These reforms introduced “Social Forestry” programmes as an opportunity for inclusive and participatory

models of forest governance in the late 2000's (Contreras-Hermosilla and Fay, 2005; Wollenberg et al., 2009). Under a more recent Social Forestry initiative in 2015, the Indonesian government committed to allocating 12.7 Mha (or 10%) of forested land across Indonesia to marginalized communities (MEF, 2015).

Indonesia's social forestry programmes broadly aim to restore forests, better manage existing degraded land, improve social welfare, and support sustainable livelihoods (MEF, 2015; Santika et al., 2017). The most expansive type within the Borneo region of the country, *Hutan Desa* (translated as "Village Forest"), has been promoted as a mechanism for alleviating poverty, ensuring equitable access to land, and improving forest management. *Hutan Desa* aligns with the dominant model of CFM in Southeast Asia, in which programmes are planned at the national level of government, forest land remains in State hands, and the acquisition of legal permits and management rights requires an application process involving provincial and national levels of government (Gilmour, 2016).

The *Hutan Desa* scheme allows communities to manage defined production or protection forest areas under a 35-year contract agreement with the State (Moeliono et al., 2017). But obtaining such a license - a stage we have called "Initiation" (Table 2) - involves a technically-demanding and bureaucratic process. To obtain the *hak pengelolaan hutan desa* - or management rights - a community is required to: form a forest management committee of the village institution (*lembaga pengelolaan hutan desa*); map the borders of the proposed forest working area (*Penetapan Area Kerja*); and develop a management plan for the forest. At the time of this study, this process was almost always facilitated by an outside organisation (de Royer et al., 2015; Moeliono et al., 2015). Once the permit is obtained, the management plan can be refined and implemented ("Implementation", Table 2). The land can be used for limited cultivated crops, non-timber forest product harvest, payment for ecosystem services, and some timber extraction, depending on the type of forest (FFI, 2012; MEF, 2016). Protection or restoration may also be included in the management plan, and patrolling borders or conducting biodiversity questionnaires could be part of this stage. Other activities are recognised as being important for the long-term sustainability of community-based forest management - such as accessing markets to sell products, or developing alternative livelihood options (Porter-Bolland et al., 2012) - and can be considered a further "Support" stage in the process (Table 2).

2.2. Data collection

We used peer-reviewed and grey literature to first develop a basic understanding of the types of actors involved in *Hutan Desa* and the permitting process. Prior to conducting interviews, we used questionnaire responses from 132 members of village-level management bodies for *Hutan Desa* in West Kalimantan, Indonesian Borneo to establish an initial list of organisations active in villages in the region. This questionnaire was carried out in five of the villages with *Hutan Desa* in the Kapuas Hulu and Ketapang regencies (Supplemental Material, Figure S1) from April to June 2017. Respondents were asked what organisations they exchange information with related to *Hutan Desa*. We supplemented questionnaire responses with a list of participants in an existing forum - West Kalimantan's Social Forestry Working Group convened by the Provincial Forestry Service since 2016 - to develop a list of organisations with which to conduct interviews. We identified all villages with *Hutan Desa* permits in Ketapang and Kapuas Hulu from the Indonesian Ministry of Environment and Forestry's registry of Social Forestry (*PIAPS*, MEF, 2015), and used those 15 villages as the boundary for the village side of the network.

Table 2. Node and tie types coded from semi-structured interviews. Organisational ties represent how external organisations interact with each other. Ties between villages and organisations are the stages of the *Hutan Desa* process.

Node Attribute: Organisation Type	
NGO	Non-governmental organisation, including local, national, and international
Government	Includes district, provincial, and national government agencies and departments
Donor	Organisations that represented a foreign sovereign government, foundation, or funding mechanism, either providing funds or project support
Private Company	Any non-philanthropic organisation, including businesses and consultancies
Node Attribute: Primary Objective	
Social	Social objectives were stated as the primary motivation for the involvement of the organization in <i>Hutan Desa</i> , including human well-being, rights, and community development.
Conservation	Environment-oriented objectives were stated as the primary motivation of the organization for its involvement in <i>Hutan Desa</i> , including biodiversity conservation, avoiding deforestation, and climate change mitigation/carbon storage.
Organisational Ties: Interaction Type	
Collaboration	Partnering or working together on the same or related activities.
Coordination	Planning and/or carrying out complementary activities that are not part of a joint project.
Information	Providing, receiving, exchanging information; leading/attending trainings related to <i>Hutan Desa</i> .
Resources	Providing or receiving funds or raw materials (e.g. seedlings).
Village-Organisation Ties: Stages of <i>Hutan Desa</i> Process	
Initiation	Starting the process of applying for <i>Hutan Desa</i> permits (e.g. "socialisation", documentation and border definition, application submission).
Implementation	Involved in activities after permits are granted/approved to realise on the ground activities (e.g. assisting with activities outlined in the <i>Hutan Desa</i> management plan), patrolling, and M&E.
Support	Maintenance activities, not necessarily directly related to the <i>Hutan Desa</i> (e.g. capacity buildings and trainings, access to markets and finance); these are things that are not started as part of the <i>Hutan Desa</i> plans, but could affect the "success" of <i>Hutan Desa</i> communities.

Between October 2017 and March 2018, we carried out 43 semi-structured interviews (60-90 minutes each), with district and provincial government, NGO representatives, donor organisations, private entities (e.g. consultancies), and leaders of the village-level forest management bodies. Interviews were mostly conducted in Bahasa Indonesia with an English language interpreter, and covered interactions related to *Hutan Desa* with other organisations and in villages, as well as the organisation's motivation for involvement in *Hutan Desa* ("primary objective"). We used respondent-driven snowball sampling to identify additional stakeholders to approach subsequently, and continued until we reached a point of saturation, where no new organisations were mentioned (Newing et al., 2011, p.74-75). Organisations that professed no relation to *Hutan Desa* (even if named by other respondents) or were not active in either of our two study regencies, were considered outside the boundary of the network. Semi-structured interviews and snowball sampling have been used previously in similar research to identify nodes and ties, as well as to contextualise and qualify the network analysis by providing narrative explanation for some of the emerging patterns (Lauber et

al., 2008; Schusser, 2013). Human research ethics clearance was obtained through the University of Queensland (#2017000798), and informed consent was obtained from all participants prior to data collection.

2.3. Data analysis

We transcribed and then coded interviews for types of interactions between different stakeholders, activities within villages, and primary objectives for involvement in *Hutan Desa*, using the RQDA package (Huang, 2016) in R Studio version 3.4.4 (Team, 2018). In this analysis, nodes represented either organisations or villages. We developed the networks from the coded interviews based on the types of social interactions between actors (nodes) (Table 2). The social interactions (or ties in the network) between organisations included information exchange, collaboration, coordinated activities, and resources transfer. For the analysis, these different tie types were simplified to a generic interaction between actors. Between villages and organisations, ties represented whether an organisation was involved in initiating the *Hutan Desa* process, implementing the management plan and activities, or providing support beyond those activities. We did not measure interactions between the various villages. Characteristics of actors (e.g. organization type, primary objective) were included as node attributes. By coding the semi-structured interviews, the types of ties and node attributes were developed inductively (Williams and Shepherd, 2017). We constructed three multi-level networks from our raw data, with each separate network representing a different stage in the *Hutan Desa* process (Links to Community, Figure 2). The networks captured (1) ties between various organisations, and (2) ties between organisations and villages (meso-level, Wang et al., 2013).

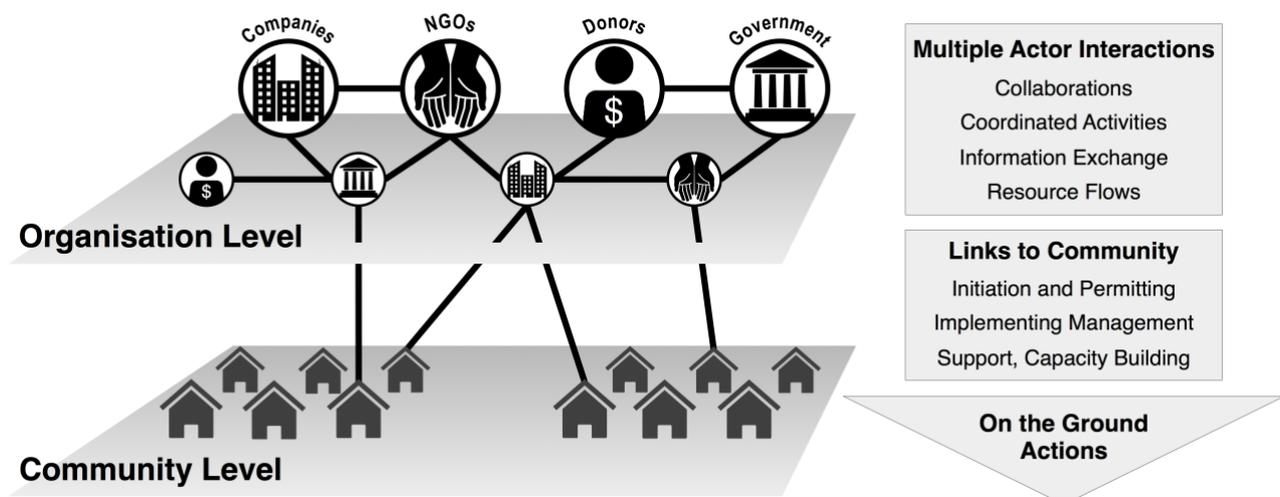


Figure 2. Conceptual diagram depicting types of stakeholders and interactions in a multi-level community forestry network. Multiple actor interactions - ties between organisational nodes – comprise the organisational level of the network. Links to the community – ties between organisational and village nodes - represent specific stages in the *Hutan Desa* process. In this multilevel network, a subset of stakeholders interacts with both villages and the broader network of organisations.

To examine key social processes for governing forest resources, we fitted Exponential Random Graph Models (ERGMs) using the MPNet software (Wang et al., 2009). ERGMs provide a type of statistical model appropriate for networks that allows for the comparison between structural configurations (due to the presence or absence of ties) in a network of interest and those resulting from running multiple simulated random networks (Berardo, 2014). Unlike traditional linear models, ERGMs assume that configurations are conditionally dependent, and thus when an actor or tie changes it affects other actors and ties (Wang et al., 2013). The central assumption is that network ties do not form entirely at random, which allows us to link patterns that emerge to social processes

(*ibid*). Density was fixed for the network of ties between villages and organisations, and between organisations, functioning in MPNet as an “activity” tie in each of the networks.

We based configurations of interest on existing conceptual and empirical literature summarized earlier in the conceptual framework (Figure 1; Table 1). After baseline configurations had been fitted, we added attribute variables to see if interactions with organisations of the different type or primary objective (“mismatching”) significantly contributed to the network structure. We used the composite network of the different tie types representing a generic interaction between external actors, and then fit ERGMs to the multi-level network at each of the three *Hutan Desa* stages. For each model, we used a goodness-of-fit procedure that compared observed configuration counts to those of 1000 random graphs generated from the specified parameters, to ensure that the models describe the observed distribution of all configurations well (Guerrero et al., 2015).

3. Results

3.1 What types of actors are in the network?

There are multiple organisations outside of communities involved in making *Hutan Desa* possible. In total, 52 organisations - 21 in Ketapang, 21 in Kapuas Hulu, and 10 in both regencies - were identified as active in *Hutan Desas* in the two study regencies (Table 3a). Fourteen were based at the regency level, 11 at the province, 10 are national, and 17 are international.

Table 3. a) Count of actors included in the analysis, by type of organisation and primary objective. b) Number of organisations by type active in at least one village at each stage in the *Hutan Desa* process.

Org Type	a) Objective		b) <i>Hutan Desa</i> Stage		
	Conservation	Social	Initiation	Implementation	Support
Donor	5	3	1	3	2
Government	5	9	4	2	2
NGO	15	10	8	8	14
Private Company	3	2	1	1	1

3.2. The actors working with villages

Fifteen communities with *Hutan Desa* were identified in the two study sites. Of the 52 organisations, 29 engaged directly with one or more village, at some stage in the process. More villages had multiple organisations active during the Initiation stage than during Implementation or Support stages (Figure 3a). However, the Support stage had the highest overall number of organisations active (Table 3b). Overall, NGOs were the most frequent type of organisation at any stage (Table 3b), and organisations with primarily conservation objectives were more represented during all stages of the *Hutan Desa* process (Figure 3b). The most involved organisations at the Initiation stage were conservation NGOs and government bodies. Mostly NGOs were involved with Implementation, but only two organisations were active in more than two villages, and there were no organisations involved in two of the villages during this stage. Similarly, mostly NGOs were involved at the Support stage (14/19 organisations), and three villages had no organisations active at this stage. Collaborative and coordinative ties - which usually consisted of joint or complementary projects and activities in villages - were dominated by NGOs (Supplemental Material, Figure S2), further highlighting the role of these organisations in on-the-ground *Hutan Desa* actions.

The nature of an organisation’s interactions with villages at the Implementation and Support stages is of particular relevance to longevity and long-term sustainability of *Hutan Desa*. Some interview respondents raised concerns over maintenance and longevity of the programme, acknowledging the need to build local engagement, capabilities, connections, and *rasa memiliki* – a sense of ownership, as one respondent put it – among villagers. Interviews with village leaders suggested that the current approach to *Hutan Desa* elevates the permit as the end goal, rather than the beginning. Furthermore, interviews suggested that the dominance of NGOs at later stages in the *Hutan Desa* process was not ideal. For instance, government actors mostly provided information and convened meetings, relying on their “*teman-teman* NGO” - or NGO friends - to carry out administrative and technical components for *Hutan Desa* and liaise with community leaders. Based on interviews, there was the perception that in practice relevant district government bodies should be involved in technical assistance, management implementation, and enforcement on-the-ground.

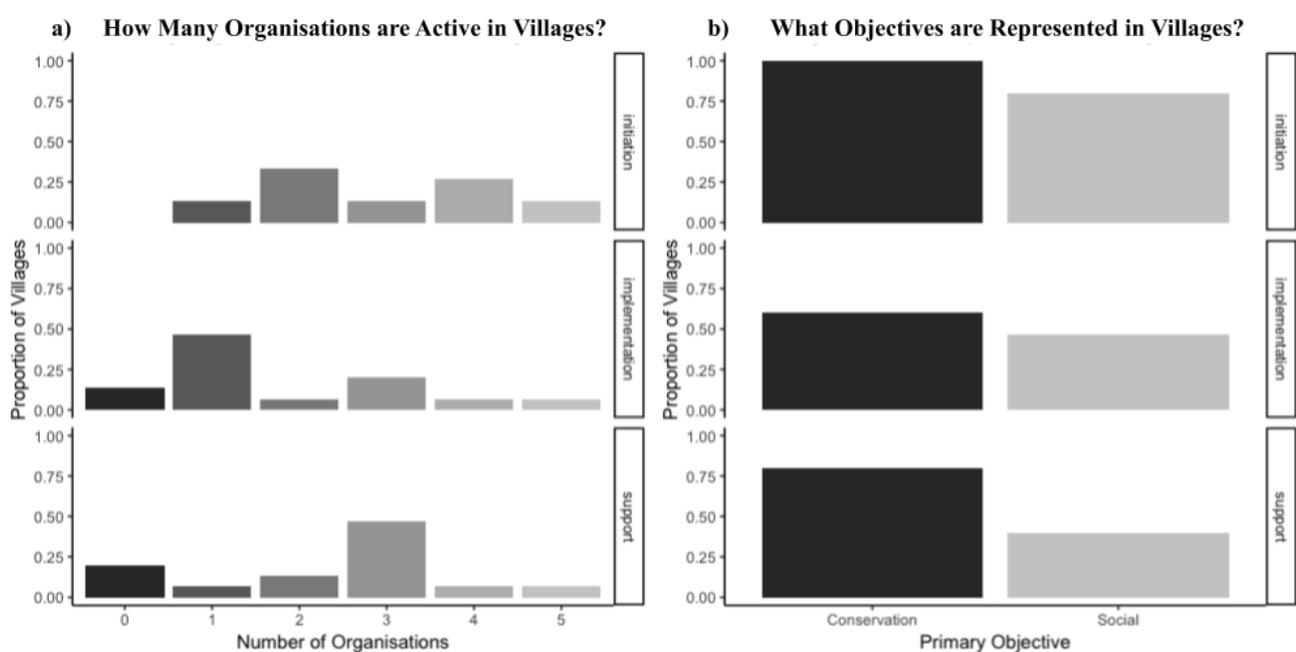


Figure 3. a) Proportion of villages with one or more organisations active at different stages in the *Hutan Desa* process. b) Proportion of villages that have organisations with conservation or social objectives active at different stages.

3.3. A network of bridging and coordination

The multi-level networks (Figure 4) all followed similar patterns of baseline network configurations: more multi-level bridging configurations between villages and the external organisational network than expected by chance alone (StarAXAB, StarAB1X; Table 4). Only during Initiation was there significant evidence of bonding between organisations active in the same villages (TriangleXBX), suggesting cooperation between organisations. At the Initiation stage, there were significantly fewer matches of primary objectives (i.e. organisations with the same objectives were less likely to be active in the same village). Together with triangle configurations, this network structure indicates bonding social capital across actors with different objectives. This may be due to prominent involvement by government actors with social motives and conservation NGOs. During Implementation and Support stages, there was more-than-expected matching of organization type, suggesting homogeneity of organisations involved in villages, likely due to the ubiquity of NGOs. As there are no significant bonding configurations, there is not necessarily cooperation between these organisations.

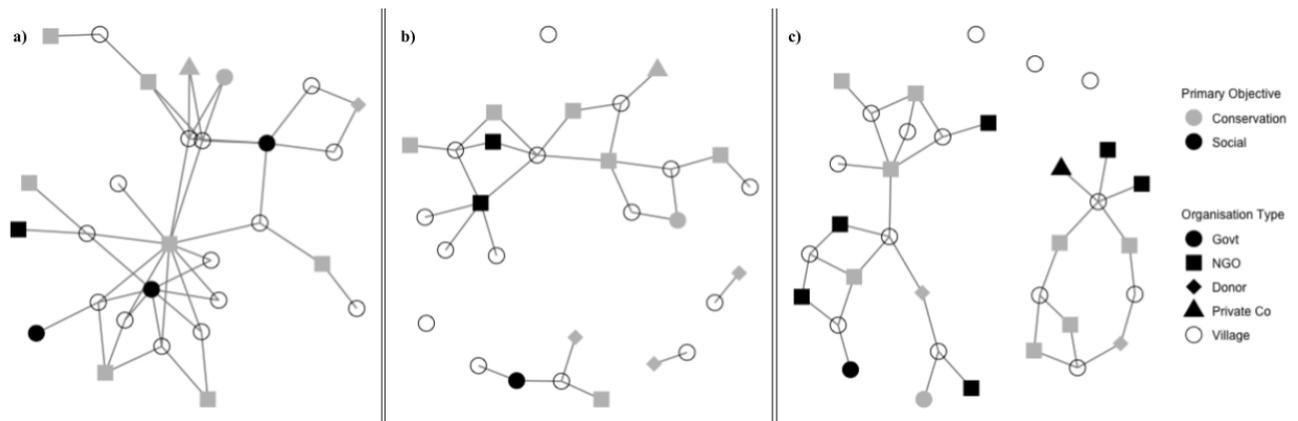


Figure 4. Networks of all organisational actors active in villages at: a) Initiation, b) Implementation, c) Support stages.

Table 4. Results for multi-level ERGMs at each stage of the *Hutan Desa* process. Density was fixed for the network of ties between villages and organisations, and between organisations.

		a) Initiation		b) Implementation		c) Support	
Baseline Configurations		Param est (t-stat)	Counts (t-stat)	Param est (t-stat)	Counts (t-stat)	Param est (t-stat)	Counts (t-stat)
StarAB1X		0.97 (-0.049)*	1013.04 (0.194)	0.67 (-0.047)*	384.60 (-0.094)	0.99 (0.044)*	658.96 (0.113)
StarAXAB		1.75 (-0.041)*	821.69 (0.057)	2.08 (0.04)*	784.30 (-0.012)	1.86 (0.093)*	801.93 (0.034)
TriangleXBX		1.055 (-0.005)*	32 (0.139)	0.40 (-0.087)	6 (-0.333)	-0.12 (-0.006)	11 (0.042)
Node Attributes							
Star match org type		0.024 (0.002)	21 (-0.017)	0.35 (0.076)*	18 (-0.34)	0.33 (-0.044)*	24 (0.11)
Star match objective		-0.75 (0.052)*	26 (0.014)	-0.14 (0.089)	14 (-0.335)	-0.032 (-0.055)	22 (0.085)

* significant when absolute value of the parameter estimate is greater than twice the size of the standard error (Wang et al., 2013) § configurations required for model to reach acceptable goodness of fit can be found in Table S1.

4. Discussion

This study examined the development of community-based forest management through the interactions of the multiple actors involved in a *Hutan Desa* network in Indonesian Borneo. Our analysis illustrates the cooperation between actors early in the process, and the roles of certain external actors linking the broader organisational network to action on-the-ground throughout the process. It also depicts the shifts in types and objectives of actors from Initiation through Implementation and Support stages, hinting at the importance of different characteristics in the network over time. The following discussion elaborates on these points, while also noting shortcomings and future directions of this research.

4.1 Cooperation and heterogeneity are important early in the *Hutan Desa* process

The *Hutan Desa* networks depicted significant bonding configurations only during the Initiation stage. This could be an indication of how organisations might need to work closely with each other – sharing information or contributing different expertise – when first embarking on the *Hutan Desa* application process. This is an intuitive finding, as there is a clear goal during Initiation to obtain the management rights and permit for the *Hutan Desa*. As such, there may not be many apparent barriers to building close relationships at this point, and the risk associated with not working together toward a common goal may be high. The heterogeneity of objectives at this stage might be indicative of the importance of cooperation between NGOs (predominantly conservation-motivated) and government (with social objectives for *Hutan Desa*), which are both active in villages to provide information – “socialisation” – and start the application process. These patterns corroborate the hypothesis for governance networks that early in natural resources policy processes, when the nature of exchanges between organisations is still uncertain and risks from inadequate accountability may be high, bonding interactions form in order to build trust and reciprocal relationships (Berardo and Scholz, 2010). In the *Hutan Desa* case, we might have seen lower representation of either of these organisations in villages, had there be no bonding ties.

4.2 Bridging policy and practice characterises the networks

Our results highlight the prevalence of bridging configurations in the networks. This aligns with the need in decentralised governance to manage discrepancies between where policy is set and where it is implemented (Gallemore and Munroe, 2013; Mahanty et al., 2009), and to translate or coordinate across scales (Adger et al., 2006; Rathwell and Peterson, 2012). The prominence of bridging configurations at Initiation reflects how Indonesia’s *Hutan Desa* licensing process requires technical knowledge outside of villages to draft workplans and complete permitting applications (de Royer and Juita, 2016). In particular, NGOs (both regional and international) have to liaise with provincial and national government actors for updated information on the regulation and for application approvals, or with donors to fund their activities in villages.

Bridging configurations at Implementation and Support stages highlight how organisations expand the reach of communities, and could indicate the infusion of outside knowledge or connection to markets, which are important in these later stages. Bridging social capital might imply that those organisations that interact (either directly or indirectly) at these stages have well-established operational norms, and unlike during Initiation do not require the same bonding capital to govern their conduct (e.g. Berardo and Scholz, 2010; McCallister et al., 2015). Considering organisations of the same type (i.e. NGOs) dominate activities at the village level, in the case of CFM it may be that these organisations already understand and trust each other, thus leaving less uncertainty about their activities.

While mediation between governance levels is crucial to ensure that national policy can operate at local levels, there is also the potential for power asymmetries and dependence on external organisations to result (Benson, 2012; Calfucura, 2018; Lund et al., 2018). Previous studies have critiqued how long-term success often hinges on continued outside financial and institutional support, requiring bridges between the community level and external authorities (Baynes et al., 2015; Newig and Fritsch, 2009). As such, bridging roles should proceed cautiously, with an eye toward truly building local capacity and engagement, especially considering the trend in the last few decades of increasing reliance on NGOs in a variety of natural resources management and conservation efforts (Brockington and Scholfield, 2010; Espinosa-romero et al., 2014). External organisations can have positive influences on outcomes if sufficiently interactive at local levels, which the bridging seen in our study suggests is the case. Because directly affected local-level stakeholders may be best suited to resolve resource degradation problems (Ostrom, 2000), there is still a need to ensure that

interactions with external actors actually improves requisite local management capacity to achieve benefits (Fisher et al., 2017).

4.3 What organisations want – the place of primary objectives

Social capital and cooperation contribute to achieving diverse goals of multiple actors (Adger 2003; Baral 2012; Barnes, et al. 2018; Berardo 2014; Henry & Vollan 2014; Robins, et al. 2011). This suggests that interactions with a range of actor types and motivations may be important for integrating diverse knowledge and developing innovative solutions to resource governance challenges. While the analysis depicted significantly more matching of organisation type during Implementation and Support, there was no clear pattern for primary objectives (though the estimate suggests a mismatch during Implementation and a match during Support). Homogeneity of organization type is not necessarily negative at these stages, as multiple specialized NGOs with different expertise may be most suited to carrying out the associated activities, and as mentioned above, may not require close cooperation to do so. That said, the lack of bonding social capital generally – whether across different types of actors or with different objectives – during the Implementation and Support stages might also be considered a shortcoming when considering the capacity to communicate, negotiate, and resolve conflicts in natural resources governance over time (McCallister et al., 2015b).

In the Initiation stage, there are indications of cooperation between organisations with different objectives, likely between NGOs and government. However, this disappears in the later stages, perhaps an indication of lack of clarity over certain actors' roles in Indonesia's social forestry programme. For instance, recent studies in Indonesia have shown that, despite expectations for district level forest management units (KPH) to act as implementer of forest policies, the rapid policy changes and shifts in authority have made it difficult for KPH to be clear about their responsibilities or to develop a workplan (de Royer and Juita, 2016; Fisher et al., 2017). Much of the involvement of these actors in *Hutan Desa* thus far has been information dissemination.

Finally, there appears to be an emphasis on conservation and biodiversity throughout the process, which might understate the need for social support – in terms of livelihood capacities, community building, and empowerment – to ensure the long-term success of *Hutan Desa*. For instance, lack of knowledge or access to markets for forest products is considered a fundamental barrier to successful community-based forest management (Gilmour, 2016). In the networks here, the presence of some organisations driven by social objectives offers encouragement, and could be particularly crucial during the Support stage to move toward dual social and ecological outcomes. However, they are still dwarfed in number by organisations with conservation goals.

4.4 Caveats and future research

While the application of social network analysis here offers insight into roles and interactions of different actors in a community-based forest management network, there are potential shortcomings and areas for future research. First of all, though delimiting the “network boundary” is accepted as a critical first step, it is not without difficulty (Newig et al., 2010). We collected as complete a network as possible by reaching a point of saturation, but what defined an organisation as being involved in *Hutan Desa* was not always straightforward, thus leaving room for interpretation of the network boundary. Further research could explore how community forest activities are connected to other projects and organisations within villages that are not specifically tied to *Hutan Desa* but have relevance (e.g. development projects). This could be particularly insightful during the Support stage, where collaboration or assistance from organisations less directly involved in community forests might still be critical for long-term viability of alternative livelihoods from forests.

Another challenge we confronted relates to the temporal element. *Hutan Desa* has only been in play for at most eight years in our study sites, with each community initiating at different points in time. The relatively recent nature of *Hutan Desa*'s accelerated permitting (2015) might also explain the general lack of long-term investment (de Royer and Juita, 2016), which could affect the activities and interactions we see during Implementation and Support stages. While it would be informative to see the changing landscape of organisations over time, especially as more actors become involved in *Hutan Desa* (and Social Forestry initiatives more broadly), using the stages in the process allowed us to aggregate the experiences of villages and address the relatively short time period available for study. However, it is expected that the configurations during these later stages might continue to develop as the initiative ages.

Future analyses could also integrate village-level networks to better understand how interactions at different levels contribute to community forest management. Our study benefitted from a readily-accessible network of stakeholders in the case study districts, including existing contacts. With more replication in different districts, and concrete outcome variables, this network structure could also be more closely tied to procedural challenges and performance of community-based forest management. This could be taken further to compare across national policy contexts (Brooks et al., 2012), especially considering the extent of decentralised governance cases in Southeast Asia.

4.5 Conclusion

Our study demonstrates how applying a network approach can improve our understanding of how stakeholder interactions evolve over the course of developing community-based forest management. As gathered from existing literature on community-based forest management, cooperation and heterogeneity of actor characteristics at key moments are considered important for the success and resilience of such programmes over the long-term. Our analysis showed the common thread of bridging social capital across stages, but bonding only at the start. This may be a sign that as long as the necessary pieces are in place early in the process, close relationships between organisations may not be critical to invest in and maintain for the longer term. However, this lack of bonding could also be an early warning that capacity for conflict resolution and collaboration for the longer-term have been undermined.

Furthermore, the prominence of conservation NGOs in *Hutan Desa* is not surprising, however, it does suggest a need for greater balance of objectives. This could influence how knowledge, access, and resources manifest in the network, and ultimately whether programmes can deliver on both their social and environmental objectives. The findings from this study can provide initial insight for organizations engaged in developing and implementing such programmes, and serve as a foundation for further research. Current government plans in Indonesia have expanded rapidly and merit scrutiny over how the network of actors supporting this effort has developed. Hopefully, this will benefit other Southeast Asian countries (such as Bangladesh, Nepal, and Bhutan) that are also maintaining or expanding their decentralised forest governance initiatives (Buffum, 2012; Rasul et al., 2011).

6. References

- Adger, W.N., 2003. Social Capital, Collective Action, and Adaptation to Climate Change. *Econ. Geogr.* 79, 387–404. <https://doi.org/10.1111/j.1944-8287.2003.tb00220.x>
- Adger, W.N., Brown, K., Tompkins, E.L., 2006. The Political Economy of Cross-Scale Networks in Resource Co-Management. *Ecol. Soc.* 10(2), 9. <http://www.ecologyandsociety.org/vol10/iss2/art9/>
- Agrawal, A., Chhatre, A., Hardin, R., 2008. Forests in Flux. *Science.* 320(5882), 1460–1462. <https://doi.org/10.1126/science.320.5882.1435>
- Alexander, S.M., Andrachuk, M., Armitage, D., 2016. Navigating governance networks for community-based conservation. *Front. Ecol. Environ.* 14(3), 155–164. <https://doi.org/10.1002/fee.1251>
- Alexander, S.M., Armitage, D., Charles, A., 2015. Social networks and transitions to co-management in Jamaican marine reserves and small-scale fisheries. *Glob. Environ. Chang.* 35, 213–225. <https://doi.org/10.1016/j.gloenvcha.2015.09.001>
- Angst, M., Widmer, A., Fischer, M., Ingold, K., 2018. Connectors and coordinators in natural resource governance: insights from Swiss water supply. *Ecol. Soc.* 23(2), 1. <https://doi.org/10.5751/ES-10030-230201>
- Baral, N., 2012. Empirical analysis of factors explaining local governing bodies' trust for administering agencies in community-based conservation. *J. Environmental Manag.* 103, 41–50. <https://doi.org/10.1016/j.jenvman.2012.02.031>
- Barnes-Mauthe, M., Arita, S., Allen, S.D., Gray, S.A., Leung, P., 2016. The Influence of Ethnic Diversity on Social Network Structure in a Common-Pool Resource System: Implications for Collaborative Management. *Ecol. Soc.* 18(1), 23. <https://doi.org/10.5751/ES-05295-180123>
- Barnes, M., Bodin, O., Guerrero, A., McAllister, R., Alexander, S., Robins, G., 2017. The social structural foundations of adaption and transformation in social-ecological systems. *Ecol. Soc.* 22(4), 16. <https://doi.org/10.5751/ES-09769-220416>
- Barnes, M., Kalberg, K., Pan, M., Leung, P.S., 2016. When is brokerage negatively associated with economic benefits? Ethnic diversity, competition, and common-pool resources. *Soc. Networks* 45, 55–65. <https://doi.org/10.1016/j.socnet.2015.11.004>
- Baynes, J., Herbohn, J., Smith, C., Fisher, R., Bray, D., 2015. Key factors which influence the success of community forestry in developing countries. *Glob. Environ. Chang.* 35, 226–238. <https://doi.org/10.1016/j.gloenvcha.2015.09.011>
- Bell, J., Morrison, T., 2015. A Comparative Analysis of the Transformation of Governance Systems : Land-Use Planning for Flood Risk. *J. Environ. Policy Plan.* 17(4), 516–534. <https://doi.org/10.1080/1523908X.2014.986567>
- Benson, C., 2012. Conservation NGOs in Madang, Papua New Guinea: Understanding Community and Donor Expectations. *Soc. Nat. Resour.* 25(1), 71–86. <https://doi.org/10.1080/08941920.2011.603141>
- Berardo, R., 2014. Bridging and bonding capital in two-mode collaboration networks. *Policy Stud. J.* 42(2), 197–225. <https://doi.org/10.1111/psj.12056>
- Berardo, R., Scholz, J.T., 2010. Self-Organizing Policy Networks: Risk, Partner Selection, and Cooperation in Estuaries. *Am. J. Pol. Sci.* 54(3), 632–649. <https://doi.org/10.1111/j.1540-5907.2010.00451.x>
- Bodin, Alexander, S.M., Baggio, J., Barnes, M.L., Berardo, R., Cumming, G.S., Dee, L.E., Fischer, A.P., Fischer, M., Mancilla Garcia, M., Guerrero, A.M., Hileman, J., Ingold, K., Matous, P., Morrison, T.H., Nohrstedt, D., Pittman, J., Robins, G., Sayles, J.S., 2019. Improving network approaches to the study of complex social-ecological interdependencies. *Nat. Sustain.* 2, 551–559. <https://doi.org/10.1038/s41893-019-0308-0>
- Bodin, Ö., Crona, B., Ernstson, H., 2006. Social Networks in Natural Resource Management: What Is There to Learn from a Structural Perspective? *Ecol. Soc.* 11(2), r2. <http://www.ecologyandsociety.org/vol11/iss2/resp2/>

- Bodin, Ö., Crona, B.I., 2008. Management of Natural Resources at the Community Level: Exploring the Role of Social Capital and Leadership in a Rural Fishing Community. *World Dev.* 36(12), 2763–2779. <https://doi.org/10.1016/j.worlddev.2007.12.002>
- Bodin, Ö., Robins, G., McCallister, R.R.J., Guerrero, A.M., Crona, B., Tengö, M., Lubell, M., 2016. Theorizing benefits and constraints in collaborative environmental governance : a transdisciplinary social-ecological network approach for. *Ecol. Soc.* 21(1), 40. <https://doi.org/10.5751/ES-08368-210140>
- Borg, R., Toikka, A., Primmer, E., 2015. Social capital and governance: A social network analysis of forest biodiversity collaboration in Central Finland. *For. Policy Econ.* 50, 90–97. <https://doi.org/10.1016/j.forpol.2014.06.008>
- Borgatti, S.P., Mehra, A., Brass, D.J., Labianca, G., 2009. Network Analysis in the Social Sciences. *Science.* 323(5916), 892–896. DOI: 10.1126/science.1165821
- Brockington, D., Scholfield, K., 2010. The Conservationist Mode of Production and Conservation NGOs in sub-Saharan Africa. *Antipode* 42(3), 551–575. <https://doi.org/10.1111/j.1467-8330.2010.00763.x>
- Brooks, J.S., Waylen, K.A., Borgerhoff Mulder, M., 2012. How national context, project design, and local community characteristics influence success in community-based conservation projects. *Proc. Natl. Acad. Sci.* 109(52), 21265–21270. <https://doi.org/10.1073/pnas.1207141110>
- Buffum, B., 2012. Why is There No Tragedy in These Commons? An Analysis of Forest User Groups and Forest Policy in Bhutan. *Sustainability* 4(7), 1448–1465. <https://doi.org/10.3390/su4071448>
- Calfucura, E., 2018. Governance, Land and Distribution: A Discussion on the Political Economy of Community-Based Conservation. *Ecol. Econ.* 145, 18–26. <https://doi.org/10.1016/j.ecolecon.2017.05.012>
- Cash, D.W., Adger, W.N., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, L., Young, O., 2006. Cross-Scale Dynamics: Governance and Information in a Multilevel World. *Ecol. Soc.* 11(2), 8. <http://www.ecologyandsociety.org/vol11/iss2/art8/>
- Cohen, M., Baudoin, R., Palibrk, M., Persyn, N., Rhein, C., 2012. Urban biodiversity and social inequalities in built-up cities: New evidences, next questions. The example of Paris, France. *Landsc. Urban Plan.* 106(3), 277–287. <https://doi.org/10.1016/j.landurbplan.2012.03.007>
- Contreras-Hermosilla, A., Fay, C., 2005. Strengthening Forest Management in Indonesian Through Land Tenure Reform: Issues and Framework for Action. Washington, D.C., USA. *Forest Trends*.
- de Royer, S., Juita, R., 2016. Village Forest licences (Hutan Desa) in West Kalimantan: Way forward for equity and land security? Brief No. 58. Bogor, Indonesia. World Agroforestry Centre (ICRAF) Southeast Asia Regional Program.
- de Royer, S., Juita, R., Galudra, G., Pradhan, U., 2015. Are Village Forest licences for rural development or conservation? A case study from Jambi Province, Indonesia. Brief No 53. Bogor, Indonesia. World Agroforestry Centre (ICRAF) Southeast Asia Regional Program.
- Ernstson, H., Barthel, S., Andersson, E., 2010. Scale-Crossing Brokers and Network Governance of Urban Ecosystem Services: The Case of Stockholm. *Ecol. Soc.* 15(4), 28. <http://www.ecologyandsociety.org/vol15/iss4/art28/>
- Espinosa-romero, M.J., Rodriguez, L.F., Hudson, A., Villanueva-aznar, C., Torre, J., 2014. The changing role of NGOs in Mexican small-scale fisheries : From environmental conservation to multi-scale governance. *Mar. Policy* 50(A), 290–299. <https://doi.org/10.1016/j.marpol.2014.07.005>
- Fisher, L.A., Kim, Y.-S., Latifah, S., Mukarom, M., 2017. Managing Forest Conflicts: Perspectives of Indonesia's Forest Management Unit Directors. *For. Soc.* 1(1), 8. <https://doi.org/10.24259/fs.v1i1.772>
- Fisher, R.J., 1999. Decentralization and Devolution of Forest Management in Asia and the Pacific. *FAO Working Paper Series No. 21*. Rome, Italy. Food and Agriculture Organisation of the United Nations.
- Flora Fauna Indonesia (FFI), 2012. Community Forest Ecosystem Services, Indonesia Plan Vivo Project Idea Note

(PIN). Jakarta, Indonesia. Fauna and Flora International - Indonesia Programme.

- Gallemore, C., Di Gregorio, M., Moeliono, M., Brockhaus, M., H., R.D.P., 2015. Transaction costs, power, and multi-level forest governance in Indonesia. *Ecol. Econ.* 114, 168-179. <https://doi.org/10.1016/j.ecolecon.2015.03.024>
- Gallemore, C., Munroe, D.K., 2013. Centralization in the global avoided deforestation collaboration network. *Glob. Environ. Chang.* 23(5), 1199–1210. <https://doi.org/10.1016/j.gloenvcha.2013.04.004>
- Garcia-Amado, L.R., Perez, M.R., Iniesta-Arandia, I., Dahringer, G., Reyes, F., Barrasa, S., Pérez, M., 2012. Building ties: Social capital network analysis of a forest community in a biosphere reserve in Chiapas, Mexico. *Ecol. Soc.* 17(3), 3. <https://doi.org/10.5751/ES-04855-170303>
- Gilmour, D., 2016. Forty years of community-based forestry: A review of its extent and effectiveness. Rome, Italy. Food and Agriculture Organization of the United Nations.
- Górriz-Mifsud, E., Secco, L., Pisani, E., 2016. Exploring the interlinkages between governance and social capital: A dynamic model for forestry. *For. Policy Econ.* 65, 25–36. <https://doi.org/10.1016/j.forpol.2016.01.006>
- Guerrero, A.M., Mcallister, R.R.J., Wilson, K.A., Noss, R., 2015. Achieving Cross-Scale Collaboration for Large Scale Conservation Initiatives. *Conserv. Lett.* 8(2), 107–117. <https://doi.org/10.1111/conl.12112>
- Hansen, M.C., Potapov, P. V, Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S. V, Goetz, S.J., Loveland, T.R., 2013. High-resolution global maps of 21st-century forest cover change. *Science.* 342, 850–853. <https://doi.org/10.1126/science.1244693>
- Henry, A.D., Vollan, B., 2014. Networks and the Challenge of Sustainable Development. *Annu. Rev. Environ. Resour.* 39, 583–610. <https://doi.org/10.1146/annurev-environ-101813-013246>
- Huang, R., 2016. RQDA: R-based Qualitative Data Analysis.
- Ingold, K., 2017. How to create and preserve social capital in climate adaptation policies: A network approach. *Ecol. Econ.* 131, 414–424. <https://doi.org/10.1016/j.ecolecon.2016.08.033>
- Jewitt, S.L., Nasir, D., Page, S.E., Rieley, J.O., Khanal, K., 2014. Indonesia's contested domains. Deforestation, rehabilitation and conservation-with-development in Central Kalimantan's tropical peatlands. *Int. For. Rev.* 16(4), 405–420. <https://doi.org/https://doi.org/10.1505/146554814813484086>
- Kalbar, 2013. Penempatan Transmigrasi di Kalbar Sejak Pra Pelita. Dinas Tenaga Kerja Dan Transmigrasi. Pemerintah Provinsi Kalimantan Barat. Available at: <http://disnakertrans.kalbarprov.go.id/index.php/informasi/detil/34/Penempatan-Transmigrasi-di-Kalbar-Sejak-Pra-Pelita->
- Kellert, S.R., Mehta, J.N., Ebbin, S.A., Lichtenfield, L.L., 2000. Community Natural Resource Management: Promise, Rhetoric, and Reality. *Soc. Nat. Resour.* 13(8), 705–715. <https://doi.org/10.1080/089419200750035575>
- Lauber, T.B., Decker, D.J., Knuth, B.A., 2008. Social networks and community-based natural resource management. *Environ. Manage.* 42(4), 677–687. <https://doi.org/10.1007/s00267-008-9181-8>
- Leisher, C., Temsah, G., Booker, F., Day, M., Samberg, L., Prosnitz, D., Agarwal, B., Matthews, E., Roe, D., Russell, D., Sunderland, T., Wilkie, D., 2016. Does the gender composition of forest and fishery management groups affect resource governance and conservation outcomes? A systematic map. *Environ. Evid.* 5, 6. <https://doi.org/10.1186/s13750-016-0057-8>
- Levy, M.A., Lubell, M.N., 2018. Innovation, cooperation, and the structure of three regional sustainable agriculture networks in California. *Reg. Environ. Chang.* 18(4), 1235–1246. <https://doi.org/10.1007/s10113-017-1258-6>
- Lubell, M., Jasny, L., Hastings, A., 2017. Network Governance for Invasive Species Management. *Conserv. Lett.* 10(6), 699–707. <https://doi.org/10.1111/conl.12311>

- Lund, J.F., Rutt, R.L., Ribot, J., 2018. Trends in research on forestry decentralization policies. *Curr. Opin. Environ. Sustain.* 32, 17–22. <https://doi.org/10.1016/j.cosust.2018.02.003>
- Macura, B., Secco, L., Pullin, A.S., 2015. What evidence exists on the impact of governance type on the conservation effectiveness of forest protected areas? *Knowledge base and evidence gaps. Environ. Evid.* 4, 24. <https://doi.org/10.1186/s13750-015-0051-6>
- Mahanty, S., Guernier, J., Yasmi, Y., 2009. A fair share? Sharing the benefits and costs of collaborative forest management. *Int. For. Rev.* 11(2), 268–280. <https://doi.org/https://doi.org/10.1505/ifor.11.2.268>
- Margono, B.A., Potapov, P. V., Turubanova, S., Stolle, F., Hansen, M.C., 2014. Primary forest cover loss in indonesia over 2000–2012. *Nat. Clim. Chang.* 4, 730–735. <https://doi.org/10.1038/nclimate2277>
- Marshall, G.R., 2008. Nesting, Subsidiarity, and Community-based Environmental Governance beyond the Local Level. *Int. J. Commons* 2, 75–97. <https://doi.org/10.18352/bmgn-lchr.50>
- McAllister, R.R.J., McCrea, R., Lubell, M.N., 2014. Policy networks, stakeholder interactions and climate adaptation in the region of South East Queensland, Australia. *Reg. Environ. Chang.* 14(2), 527–539. <https://doi.org/10.1007/s10113-013-0489-4>
- McAllister, R.R.J., Robinson, C.J., Maclean, K., Guerrero, A.M., Collins, K., Taylor, B.M., 2015a. From local to central: a network analysis of who manages plant pest and disease outbreaks across scales. *Ecol. Soc.* 20(1), 67. <http://dx.doi.org/10.5751/ES-07469-200167>
- McAllister, R.R.J., Taylor, B.M., Harman, B.P., 2015b. Partnership Networks for Urban Development: How Structure is Shaped by Risk. *Policy Stud. J.* 43(3), 379–398. <https://doi.org/10.1111/psj.12103>
- McKinnon, M.C., Cheng, S.H., Dupre, S., Edmond, J., Garside, R., Glew, L., Holland, M.B., Levine, E., Masuda, Y.J., Miller, D.C., Oliveira, I., Revenaz, J., Roe, D., Shamer, S., Wilkie, D., Wongbusarakum, S., Woodhouse, E., 2016. What are the effects of nature conservation on human well-being? A systematic map of empirical evidence from developing countries. *Environ. Evid.* 5, 8. <https://doi.org/10.1186/s13750-016-0058-7>
- MEF, 2016. Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia Nomor 83/MENLHK/SETJEN/KUM.1/2016 Tentang Perhutanan Sosial. Jakarta, Indonesia. Ministry of Environment and Forestry Indonesia.
- MEF, 2015. Peta Indikatif Alokasi Perhutanan Sosial (PIAPS). Jakarta, Indonesia. Ministry of Environment and Forestry Indonesia
- Moeliono, M., Mulyana, A., Adnan, H., Yuliani, E.L., Manalu, P., Balang, 2015. Village forests (hutan desa): empowerment, business or burden? Brief 51. Bogor, Indonesia. World Agroforestry Centre (ICRAF) Southeast Asia Regional Program.
- Moeliono, M., Santoso, L., Gallemore, C., 2013. REDD + policy networks in Indonesia. Brief 63. Bogor, Indonesia. World Agroforestry Centre (ICRAF) Southeast Asia Regional Program.
- Moeliono, M., Thuy, P.T., Waty Bong, I., Wong, G.Y., Brockhaus, M., 2017. Social Forestry - why and for whom? A comparison of policies in Vietnam and Indonesia. *For. Soc.* 1(2), 1. <https://doi.org/10.24259/fs.v1i2.2484>
- Newig, J., Fritsch, O., 2009. Environmental Governance : Participatory ., *Environ. Policy Gov.* 19, 197–214. <https://doi.org/10.1002/eet.509>
- Newig, J., Gunther, D., Pahl-Wostl, C., 2010. Synapses in the Network: Learning in Governance Networks in the Context of Environmental Management. *Ecol. Soc.* 15(4), 24. <http://www.ecologyandsociety.org/vol15/iss4/art24/>
- Newing, H., Eagle, C.M., Puri, R.K., Watson, C.W., 2011. *Conducting Research in Conservation: A Social Science Perspective.* New York, USA. Routelage.
- Newman, L., Dale, A., 2005. Network structure, diversity, and proactive resilience building: A response to Tompkins and

Adger. *Ecol. Soc.* 10(1), r02. <https://doi.org/10.5751/ES-01396-1001r02>

Ostrom, E., 2000. Collective Action and the Evolution of Social Norms. *J. Econ. Perspect.* 14(3), 137–158. <https://www.jstor.org/stable/2646923>

Pahl-Wostl, C., 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Glob. Environ. Chang.* 19(3), 354–365. <https://doi.org/10.1016/j.gloenvcha.2009.06.001>

Porter-Bolland, L., Ellis, E.A., Guariguata, M.R., Ruiz-Mallén, I., Negrete-Yankelevich, S., Reyes-García, V., 2012. Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *For. Ecol. Manage.* 268, 6–17. <https://doi.org/10.1016/j.foreco.2011.05.034>

Pretty, J., 2003. Social Capital and the Collective Management of Resources. *Science.* 302(5652), 1912–1914. <https://doi.org/10.1126/science.1090847>

R Core Team, 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing.

Rasul, G., Thapa, G.B., Karki, M.B., 2011. Comparative analysis of evolution of participatory forest management institutions in South Asia. *Soc. Nat. Resour.* 24(12), 1322–1334. <https://doi.org/10.1080/08941920.2010.545966>

Rathwell, K.J., Peterson, G.D., 2012. Connecting social networks with ecosystem services for watershed governance: A social-ecological network perspective highlights the critical role of bridging organizations. *Ecol. Soc.* 17(2), 24. <https://doi.org/10.5751/ES-04810-170224>

Resosudarmo, B.P., Nawir, A.A., Resosudarmo, I.A.P., Subiman, N.L., 2012. Forest Land Use Dynamics in Indonesia. Working Papers in Trade and Development no. 2012/01. Australian National University, Canberra, Australia.

RI, 2014. Rencana Pembangunan Jangka Menengah Nasional RPJMN 2015-2019. Jakarta. Indonesia. Republic of Indonesia.

Robins, G., Bates, L., Pattison, P., 2011. Network governance and environmental management: Conflict and cooperation. *Public Adm.* 89(4), 1293–1313. <https://doi.org/10.1111/j.1467-9299.2010.01884.x>

Salpeteur, M., Calvet-Mir, L., Diaz-Reviriego, I., Reyes-García, V., 2017. Networking the environment: social network analysis in environmental management and local ecological knowledge studies. *Ecol. Soc.* 22(1), 41. <https://doi.org/10.5751/es-08790-220141>

Santika, T., Meijaard, E., Budiharta, S., Law, E.A., Kusworo, A., Hutabarat, J.A., Indrawan, T.P., Struebig, M., Raharjo, S., Huda, I., Ekaputri, A.D., Trison, S., Stigner, M., Wilson, K.A., 2017. Community forest management in Indonesia : Avoided deforestation in the context of anthropogenic and climate complexities. *Glob. Environ. Chang.* 46, 60–71. <https://doi.org/10.1016/j.gloenvcha.2017.08.002>

Schusser, C., 2013. Who determines biodiversity? An analysis of actors' power and interests in community forestry in Namibia. *For. Policy Econ.* 36, 42–51. <https://doi.org/10.1016/j.forpol.2012.06.005>

Shantiko, B., 2012. Seeking harmony: Scenarios for nature conservation and agricultural development in Kapuas Hulu district, Indonesia. The Futures of Agriculture. Brief No. 18 - English. Rome, Italy. Global Forum on Agricultural Research (GFAR).

Tacconi, L., 2011. Developing environmental governance research : the example of forest cover change studies 38(2), 234–246. <https://doi.org/10.1017/S0376892911000233>

Vignola, R., McDaniels, T.L., Scholz, R.W., 2013. Governance structures for ecosystem-based adaptation: Using policy-network analysis to identify key organizations for bridging information across scales and policy areas. *Environ. Sci. Policy* 31, 71–84. <https://doi.org/10.1016/j.envsci.2013.03.004>

Wang, P., Robins, G., Pattison, P., 2009. PNet: program for the simulation and estimation of exponential random graph models. Melbourne, Australia. Melbourne School of Psychological Sciences, The University of Melbourne.

- Wang, P., Robins, G., Pattison, P., Lazega, E., Wang, P., Robins, G., Pattison, P., Lazega, E., 2013. Exponential random graph models for multilevel networks. *Soc. Networks* 35(1), 96–115. <https://doi.org/10.1016/j.socnet.2013.01.004>
- Williams, T.A., Shepherd, D.A., 2017. Mixed Method Social Network Analysis: Combining Inductive Concept Development, Content Analysis, and Secondary Data for Quantitative Analysis. *Organ. Res. Methods* 20, 268–298. <https://doi.org/10.1177/1094428115610807>
- Wollenberg, E., Campbell, B., Dounias, E., Gunarso, P., Moeliono, M., Sheil, D., 2009. Interactive Land-Use Planning in Indonesian Rain-Forest Landscapes : Reconnecting Plans to Practice. *Ecol. Soc.* 14(1), 35. <https://www.ecologyandsociety.org/vol14/iss1/art35/>

Supplemental Methods and Results

1. Case study description

This study focused on actors involved in *hutan desa*, or Village Forests, in the regencies of Ketapang and Kapuas Hulu, West Kalimantan province of Indonesian Borneo. Both of these regencies have established *Hutan Desa* and accessible networks of stakeholders. Ketapang is a regency covering around 30,000 km² on the west-central coast of the island. The regency has seen expansion of plantation agriculture (e.g. oil palm and rubber), with 8.5% loss of natural forest from 2000-2010 and (based on Hansen et al., 2013; Margono et al., 2014). It has also been a particular development priority of the Indonesian Government's, with 25,476 Indonesian households translocating to Ketapang under government transmigration programs between 1960 and 2013 (Kalbar, 2013). Kapuas Hulu covers a similar area of 31,000 km², in the northeastern interior of West Kalimantan. Danau Sentarum and Bukit Kerihun National Parks are located in the regency, which was designated a "conservation district" (Shantiko, 2012). The landscape is characterised by subsistence and agroforestry land uses, with only 1.8% loss of natural forest from 2000-2010 (based on Hansen et al., 2013; Margono et al., 2014). Kapuas Hulu was less of a focus for associated economic development initiatives, with only 6,318 households migrating to Kapuas Hulu under transmigration programs from 1960-2013 (Kalbar, 2013). Figure S1 highlights the five villages in which a questionnaire was conducted to develop a preliminary list of organisations for interviews.

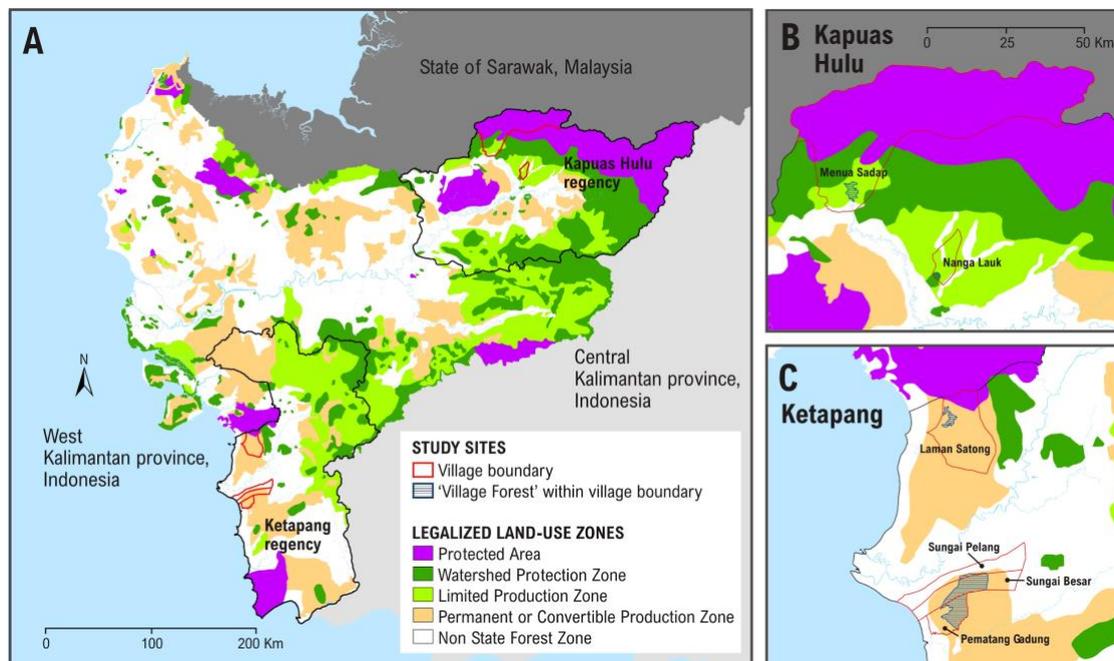


Figure S1. A household questionnaire was carried out in Nanga Lauk and Menua Sadap, Kapuas Hulu regency, and in Laman Satong, Pematang Gadung, Sungai Pelang, and Sungai Besar, Ketapang regency, from April to June 2017 by Fauna and Flora International (FFI) and University of Kent researchers. For the purposes of this study, information from this questionnaire was used only to develop an initial list of organisations to interview. (A) Sites in Kapuas Hulu and Ketapang regencies in West Kalimantan province, and panels of magnified example village sites in Kapuas Hulu (B) and Ketapang (C). Here, and elsewhere in Indonesia, *Hutan Desa* licenses are typically granted in State Forest Zones: Watershed Protection Zone (where timber harvesting is prohibited); Limited Production Zone (where timber harvesting is permitted, but within quotas); or Permanent or Convertible Production Zone (where forest clearing is permitted).

2. Supplemental Results

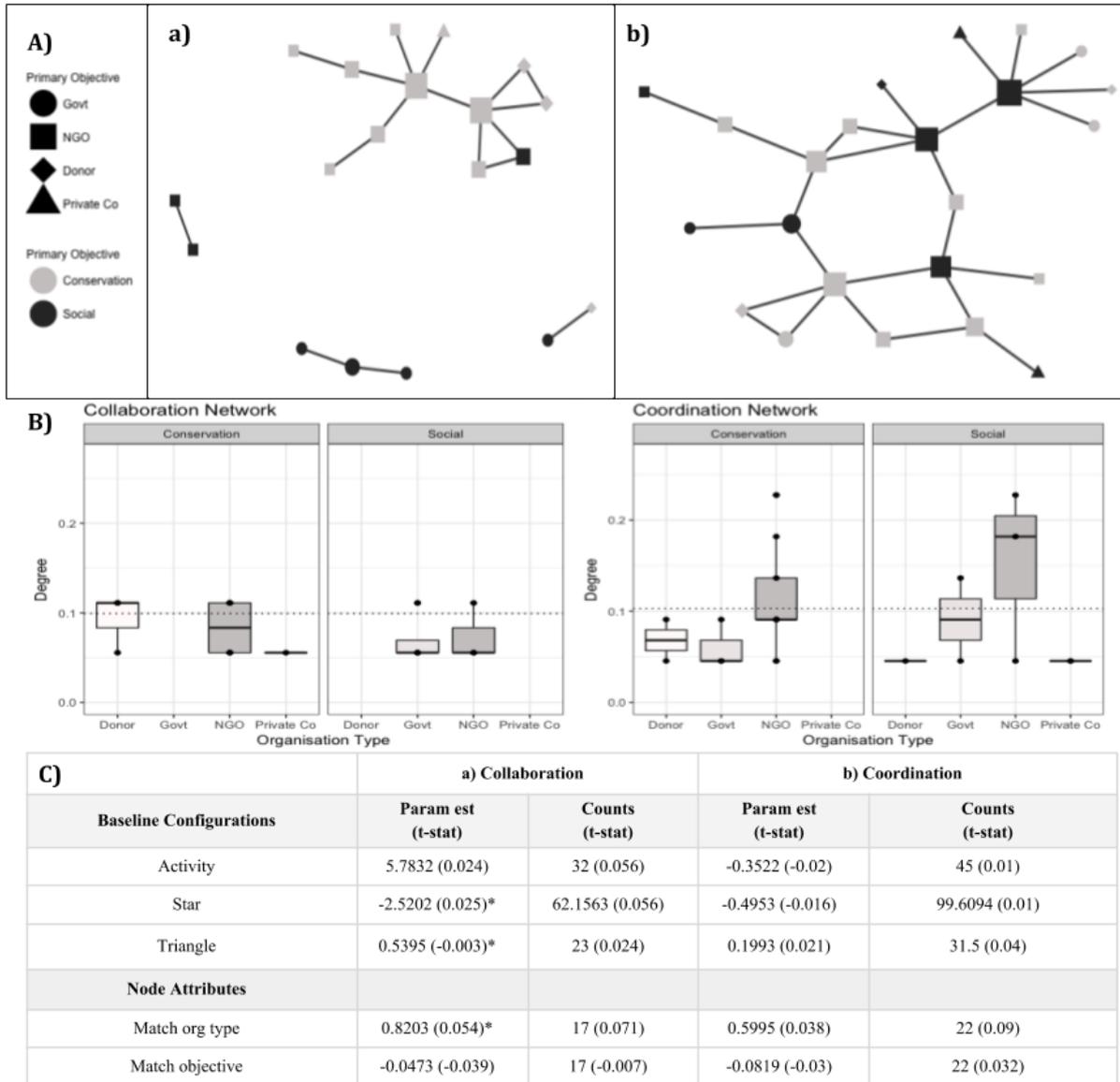
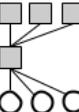


Figure S2: A) Networks of a) collaborative and b) coordinated activities. B) Degree centralities ties by organisation type and primary objective. Dotted lines represent mean degree centrality, a benchmark for highly central nodes (e.g. NGOs have above average degree for collaborative and coordinated interactions). C) Results of ERGMs show significant configurations (star, triangle, and matched organisation type) only for collaboration.

Table S1. Results for full multi-level ERGMs at each stage of the *Hutan Desa* process. Density was fixed for the network of ties between villages and organisations, and between organisations. This functions the same in MPNet as including an “activity” tie in each of the networks.

		a) Initiation		b) Implementation		c) Support	
Baseline Configurations		Param est (t-stat)	Counts (t-stat)	Param est (t-stat)	Counts (t-stat)	Param est (t-stat)	Counts (t-stat)
Star2BX		-1.72 (-0.049)*	594 (0.194)	-1.41 (-0.046)*	241 (-0.105)	-1.78 (0.043)*	397 (0.111)
StarAB1X		0.97 (-0.049)*	1013.04 (0.194)	0.67 (-0.047)*	384.60 (-0.094)	0.99 (0.044)*	658.96 (0.113)
StarAXAB		1.75 (-0.041)*	821.69 (0.057)	2.08 (0.04)*	784.30 (-0.012)	1.86 (0.093)*	801.93 (0.034)
TriangleXBX		1.055 (-0.005)*	32 (0.139)	0.40 (-0.087)	6 (-0.333)	-0.12 (-0.006)	11 (0.042)
L3XBX§		-0.085 (-0.036)	316 (0.117)	-0.052 (-0.027)	54 (-0.13)	-0.025 (0.018)	152 (0.01)
StarAX1B§		NA	633.37 (NA)	0.12 (-0.073)*	135.25 (0.163)	NA	251.25 (NA)
Node Attributes							
Star match org type		0.024 (0.002)	21 (-0.017)	0.35 (0.076)*	18 (-0.34)	0.33 (-0.044)*	24 (0.11)
Star match objective		-0.75 (0.052)*	26 (0.014)	-0.14 (0.089)	14 (-0.335)	-0.032 (-0.055)	22 (0.085)

* significant when absolute value of the parameter estimate is greater than twice the size of the standard error (Wang et al., 2013) § configuration required for model to converge and reach acceptable goodness of fit.

3. References

- Hansen, M.C., Potapov, P. V, Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S. V, Goetz, S.J., Loveland, T.R., 2013. High-resolution global maps of 21st-century forest cover change. *Science*. 342, 850–853. <https://doi.org/10.1126/science.1244693>
- Margono, B.A., Potapov, P. V., Turubanova, S., Stolle, F., Hansen, M.C., 2014. Primary forest cover loss in indonesia over 2000-2012. *Nat. Clim. Chang.* 4, 730–735. <https://doi.org/10.1038/nclimate2277>
- Kalbar, 2013. Penempatan Transmigrasi di Kalbar Sejak Pra Pelita. Dinas Tenaga Kerja Dan Transmigrasi. Pemerintah Provinsi Kalimantan Barat. Available at: <http://disnakertrans.kalbarprov.go.id/index.php/informasi/detil/34/Penempatan-Transmigrasi-di-Kalbar-Sejak-Pra-Pelita->
- Shantiko, B., 2012. Seeking harmony: Scenarios for nature conservation and agricultural development in Kapuas Hulu district, Indonesia. <https://doi.org/10.1016/j.healthpol.2006.07.009>